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Rest Pauses and Refreshments in Industry

The National Institute of Industrial Psychology has issued a Report* of unusual interest on the subject of rest pauses and refreshments in industry. The report is based on information derived from interviews with responsible executives in 1,050 factories employing about 350,000 operatives. These were evenly distributed in the industrial areas of London, Glasgow, Birmingham, Manchester, Leeds, Newcastle-upon-Tyne and Cardiff, and apparently represented purely manufacturing conditions to the exclusion of such activities as transport, shipbuilding and office staff. It was found that 52.9 per cent. of the factories visited made provision for official rest pauses. The Report discloses that a further 14.7 per cent. had unofficial rest pauses and 32.4 per cent. none at all. Rest pauses are beneficial alike to employer and operative where repetition work is carried out. This was disclosed in the original experiments which gave rise to the study. The total work done was measured over a normal working period in lifting a weight through a given height continuously until fatigue became a serious factor, and intermittently with various time spacings between rest pauses. Whilst the development of industry increases the amount of repetition work, there is still a marked percentage not entering into this category, resulting in such a diversity of effort that no rest pause is required. There is a third type of work where rest pauses are incidental to its performance. Steelmaking by the open-hearth or crucible process typifies this. Rest is usually interpreted as a period of complete idleness, but, however desirable this may be from some aspects, it is not a fundamental condition for either the mitigation of fatigue or increased production, and equally good results can be obtained by an entire change of occupation. Some shops utilise the morning and afternoon pauses for cleaning and tidying up the benches and gangways.

With the institution of rest pauses the consumption of refreshments has become rather general, and the Report devotes much space to this. There are a number of factors to be taken into consideration before finally condemning or approving of this innovation. Our personal opinion is that well-balanced meals at prolonged intervals are preferable to frequent snacks. The provision of milk between meals, though endorsed by the medical profession, is probably but the result of a tacit assumption that insufficient of this commodity is consumed with proper meals. The cases one reads of malnutrition may in a large measure be due to the irregular but frequent eating of snacks. It must be recognised, however, that climatic conditions are an important factor, as is also the average distance travelled by the operative in order to reach work. Whilst working hours have been materially reduced in recent years, the time spent in travelling to and from the works tends to increase annually. Thus no general lead can be given as to whether refreshments in the middle of the morning or afternoon are desirable.

The position is at the moment that 78 per cent. of the rest pause periods are spent in the consumption of food, and 61.5 per cent. of the workers eat in the workrooms. As washing facilities are not usually situated in the shops, it can be assumed in many cases that food is partaken with dirty hands. This cuts clean across the intention of the Factories Act and its provisions for certain industries. This report rightly condemns such a practice. Again, the existence of crumbs and leavings is a direct encouragement to entry and continuation of vermin, and only recently we saw on the notice board of one of our great research laboratories a statement that these conditions had thereby arisen.

The report carries an appendix dealing with the introduction of music into factories. Here, we, like the majority of works owners, register our objection against this innovation. Few people are sufficiently catholic to enjoy all types of music, and a personal reaction to Stravinsky would be to go out on strike! We place music on such a high plane that we believe that it is either worth undivided attention or complete exclusion. We question the statement made in the Report that "music offers possibilities of the alleviation of boredom at least," and believe it would be just as correct to suggest that "music offers possibilities of the inducement of pronounced boredom." Human beings are not yet, thank goodness, so standardised as to be universally appreciative or condemnatory of all phases of art, which usually in the highest planes only appeal to the experts.

Generally speaking, the Report fundamentally discloses nothing new, but it does show statistically how industry has reacted enthusiastically to the innovation of rest pauses during the last decade. Moreover, the concomitant feature of partaking of refreshments has received adequate attention, and no doubt shows it well responds to the present—and to our mind unsatisfactory—diatetic organisation of the working classes. Generally speaking, the townsfolk take too little interest in their meals.

* Obtainable from the Institute at Aldwych House, London, W.C.2. (Price 2s.)

Census of Production

INCREASED SCOPE OF QUESTIONS

The Census of Production Act, 1939, is a measure which simplifies the provisions concerning a general survey of production, and brings into more consonance the particulars which can be required under the Census of Production Acts and under the inquiry power of the Import Duties Act, 1932. Incidentally, matters of form filling will be easier for those firms required to make returns.

A census under the former Acts is held at intervals, the date being brought in by Statutory Order, and this census applies to practically every productive trade. An inquiry under the 1932 Act may be held every year, and in respect of any and every trade if the trades to be surveyed are published by the Board of Trade in advance. The goods concerned, however, can only be those which, if imported, are dutiable under the Import Duties Act, 1932, or the Safeguarding of Industries Act, 1921.

Procedure in a Census Year

When a census or inquiry is held, firms must complete the relevant form, and, until the passing of this 1939 Act, information could not be obtained in respect of both Acts on one form; two forms were necessary—unless certain information was given voluntarily on the one form—and the questions were different in some respects, under the 1932 Act, from those under the Census of Production Acts. This new Act now makes the questions practically the same, and so in a year of a general census there will be no inquiry under the 1932 Act.

The questions which will be asked at a census of production are the nature of the trade; particulars relating to ouput; the number of days on which work was carried on; the number of persons employed; the quantity and cost of materials used and fuel and electricity consumed; the total amount paid to contractors for work given out to them, and the power used or generated, and any questions can be asked relating to such matters of a like nature as may be found necessary for enabling the quantity and value of production to be ascertained. It should be noted that questions concerning the amount of wages paid cannot be asked, although some firms have voluntarily supplied this at times.

Alterations Involved

The alterations mostly apply to the questions concerning output and the cost of materials used and fuel and electricity consumed. Formerly, under the Census of Production Acts, the output particulars could only be required in respect of goods listed in the Import and Export List, and only to the extent of the quantitative particulars mentioned in that list. As regards cost of materials, etc., used, only an aggregate amount of the value, and only the amount of fuel, etc., used for power could be required. Details could not legally be asked for concerning these matters.

This new Act will now allow questions of the following nature to be asked: As regards materials used, separate entries will be required for different raw or semi-manufactured materials or component parts used in the production of the goods concerned, with further particulars in respect of tools, packing materials, materials used for maintenance, construction and repairs, and separate entries will be required for such items as coal, coke, gas, petrol, heavy oil and electricity used for all purposes, as well as that used for power only. As shown earlier, wages, salaries, etc., cannot be asked for and are not to be included in the cost figures asked for.

On the output side, a return will have to be made of all goods of the firm's production, whether in the Import and Export List or not.

Catalogues Received

Pig Iron. A really interesting brochure has just been released by the Stanton Ironworks Company, Limited, near Nottingham. This statement is based on the fact that it strikes a new note, by including within its contents twenty pages of pictures of castings, ranging from a few pounds to the heaviest type of machine-tool components; a batch of tear-out technical inquiry forms; and a number of pages of squared paper for making sketches, we presume, to accompany the inquiries. In addition, space has been found for some historical notes, analytical details, microstructure and fractures of a very wide range of pig-irons; some useful notes on cupola practice; and a statement as to the nature of the firm's free metallurgical service to foundries. The booklet is available to our readers on writing to Stanton.

Air Filters. The opening paragraph of a four-page leaflet received from the Visco Engineering Company, Limited, of Stafford Road, Croydon, reads: "To operate compressed-air machines and pneumatic tools at their highest efficiency, it is essential that the air should be kept free from impurities such as dirt, rust, scale, water and oil which cause loss of air and unnecessary wear and tear of the machinery." The foundry industry, which must rank as one of the largest users of compressed air, could add to these troubles the production of wasters in their enamelling shops. The operation of the filter described and illustrated depends on the expansion of the air on entering the filter, which causes a deposition of most of the extraneous matter into the sump, the remainder being arrested by a filter cell.

Fans for A.R.P. Davidson & Company, Limited, of Sirocco Engineering Works, Belfast, have in Publication No. SF309 described and illustrated a line of fans they have developed specially for A.R.P. services. Built up into units, the assembly comprises a 9-in. dia. centrifugal fan; a driving motor and switch, bevel gear and crank handles for manual operation, and the supporting framework. The publication is available to our readers on writing to Belfast.

Publications Received

Report on Economic and Commercial Conditions in Hungary. By S. V. Chambers (Acting Commercial Secretary, H.M. Legation, Budapest). Published by H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 1s. net.

The metallurgical industries of Hungary are not very important, as the annual production of pig-iron is usually less than 400,000 tons per annum. The size of the engineering and foundry industries can be gauged by the number of workmen employed, which is of the order of 48,300. Steady progress is being realised, and as the purchasing power of the agricultural workers increases expanded production can be anticipated, for the manufacture of farm implements is a major activity. The report is especially interesting, as it contains a study of the changes brought about by territorial accessions.

Letchworth in Pictures. Issued by First Garden City, Limited, Letchworth, Herts. Price 6d.

This booklet is apparently not specifically compiled so as to attract new industries to the town, but rather is it addressed to prospective residents. It is very well produced, and it has certainly achieved its object of stressing that Letchworth is a desirable place in which to live.

Random Shots

"Marksman" was interested to see that eleven out of the thirteen members of the new Advisory Panel of Supply in case of war are directly connected with the foundry industry. It is not in leadership alone, however, where talent is found in the industry, for reports from Cardiff show that one foundry owner can lay claim to being a budding detective. Three men were recently charged with safe-breaking in the foundry of Mr. Edward Matthews. The clue which led to the arrest was provided by Mr. Matthews himself, who suggested to and assisted the police in taking a sample of the dust and ballast from the safe, which was tested and found to be identical with the dust on the clothing of the men in question.

* * *

During his first year at Oxford, a young American planned a little sherry party in his rooms. He bought his sherry and then went along to the grocer's for some biscuits to go with it. "I want a box of crackers," said he in broad American accent. He was mildly surprised when the shopkeeper had to grope around at the back of a high shelf for a simple tin of biscuits, but he was much more surprised when he opened it that evening and found that his crackers were the sort that go off with a bang!

* * *

His little party, by the way, was to celebrate the May Races, which, of course, took place in June! It began to dawn on that young American why his father had insisted that a man was not "educated" unless he had been to Oxford.

* * *

Another good story about biscuits provides a little comic relief to the tragedy of the breaking up of countless wealthy country estates. An aged peer of the realm who kept up a good establishment in London as well as a country seat had occasion to consult his solicitor on the matter of rising expenses. The solicitor suggested to his client that he could easily cut down the cost of running his town house if he wished. "To begin with," he said, "why not dispense with the services of those two Italian pastrycooks you employ in your kitchen?" "What," cried the scandalised Sir Algernon, screwing his monocle to his eye, "cannot a gentleman even have a biscuit with his wine now?"

* * *

"You've got no brains and that's all there is to it," said the disgusted parent to his son on perusing the usual bad report from school. "Got no brains?" cried the astonished youngster, "Why, I've got brains that I haven't even used yet."

* * *

"Mummy," said the little boy, "I always thought Daddy could do everything." "Well, he can do most things," said a very diplomatic mother, "but what makes you say that?" "You see," replied the little chap, "he's just come home from the office looking awfully cross, and he says he's had a very trying day."

* * *

The Methodists at their recent convention have once again refused to allow women ministers within their fold. No doubt they are afraid that their congregations might be badly mishandled!

* * *

Two fellows were discussing holidays. One always spent his in England, on the plea that he hadn't seen the whole of his own country. The other preferred to go abroad, especially to France. "It's the *haute cuisine* I like mostly," he said. "It's such a change from the stuff they dish out in most English pubs."

"Go to Scotland, then," retorted the stay-at-home enthusiast. "You'll get all the oat cuisine you want!"

"MARKSMAN."

Recent Foundry Developments

REPERCUSSIONS ON PRACTICAL OPERATIONS

The extremely diverse character of modern foundry practice and how scientific discovery helps to eliminate defects and improve production were the high-lights of the second technical session held in connection with the recent International Foundry Congress in London.

The first Paper down for discussion at this session was to have been presented by MR. J. E. HURST on "Recent Developments in the Centrifugal Casting Process," but Mr. Hurst explained he had only just returned from America, and although he had started collecting data before he left, he had been unable to complete it then. Since his return, about ten days ago, there had not been time to complete it, and he felt an apology was necessary to them and in fairness to the people who had supplied the data for it. It would be completed and would be published in the Proceedings with the other Papers.

GERMAN CENTRIFUGAL CASTING PRACTICE

The first Paper presented and considered was by Mr. W. A. Geisler on "The Position of the Development of Centrifugal Casting in Germany" (see FOUNDRY TRADE JOURNAL, July 6, 13, and 20).

Commenting on this the CHAIRMAN (Major R. Miles) asked if Mr. Geisler would confirm the lengths and diameters of the largest cast-iron pipes made in Germany.

MR. W. A. GEISLER said the largest iron pipe in Germany cast centrifugally had the standard length of 5 metres and a diameter of 500 mm.

Influence of Speed of Rotation

MR. MALCOLM BROWN, after complimenting Mr. Geisler on his Paper, referred to the speed of rotation. If rotated too slowly, Mr. Geisler said, the inner surfaces of the castings were rough, the cross-section was irregular, and the castings were often permeated with blowholes. It was interesting to hear of centrifugal castings exhibiting blowholes. Was there a reason for that which the author could give?

Later in the Paper the introduction of a curtain of hot gas to prevent the formation of oxidation cracks in the finished casting was mentioned. Had the author any experience of pouring in finely ground charcoal to generate a carbonaceous atmosphere after casting, and thus prevent the cold air entering the rotor during cooling?

Replying to this question, MR. GEISLER invited his hearers to start centrifugal casting. They would find that the first thing they would produce would be, not dense castings but something like Gruyère cheese—full of blowholes. In centrifugal casting they used mainly steel or cast-iron moulds. In sand moulds the gases always had an opportunity of leaving the iron through the sand. In an iron mould it was not so easy to get rid of the gases because they had to pass through the liquid metal.

If the speed of rotation was too slow when they were casting, the iron would not remain on the outside of the mould, but would contract inwards on itself, and they would get a laminated structure in the finished casting. On the other hand, if the speed was too high, then they might apply too much pressure. Then the casting could not contract and the centrifugal force would break it while it was in the soft state. It was important always to have the correct speed, which could very easily be determined experimentally.

Referring to charcoal in order to get a smooth outside surface, for ordinary castings, such as cylinder liners, it was very important to get the correct kind of charcoal or graphite to get a smooth surface. If there was none used, they would always get blowholes. It seemed that charcoal would take care of some of the gas, or at any rate lead it away from the inside of the mould.

Manganese in Austenitic Irons

MR. T. R. TWIGGER asked, concerning an austenitic iron with only 5 per cent. nickel and no added copper mentioned in the Paper, how it could be austenitic. Was there not an appreciable amount of some other element, such as manganese? An illustration was given of a large roll made centrifugally and which rotated at 800 r.p.m. From a rough calculation the weight appeared to be at least two tons, to say nothing of the weight of the mould. That was rather a large lump to start rotating at 800 r.p.m. even though, as was mentioned, the speed was later reduced as the core metal was poured in. Were such castings made centrifugally on a production scale?

With regard to moulds lined with copper for non-ferrous work it would be interesting to know if Mr. Geisler had tried that for cast irons, and if any success had been obtained; for example, would copper-lined moulds minimise the difficulty of keeping the casting free from the blowholes which had already been mentioned, and would the moulds be more durable?

Copper-Lined Moulds

MR. GEISLER said they had to use manganese to replace the copper in their cast iron and the nickel content was about 5 per cent. Nickel was scarce in Germany and they made up for it with 12 per cent. manganese. They made, in that way, a very good austenitic iron, which was a very much cheaper iron than one with 12 to 14 per cent. nickel and 5 to 6 per cent. copper.

As to the rolls, it was a fact that they went to 2 tons in weight. Very often they had gone up to 15 tons and more; it was only a matter of building the machinery sufficiently heavy.

With reference to moulds lined with copper, that only applied to non-ferrous work. No attempt had been made to use copper in cast-iron moulds since there seemed to be no necessity for it. They used ordinary blacking and secured a very smooth casting without pinholes or other deleterious defect. Actually they achieved a smooth surface.

Tuyere Castings

MR. J. BLAKISTON asked about the advances that had been made in the centrifugal casting of copper, particularly in reference to the tuyeres and coolers. They had to be cast from a metal which had to be as near 100 per cent. purity as possible on account of the conductivity properties which were required of them. Cast copper, when passing through its freezing range, was very friable, and, on account of this, presented considerable difficulties to obtain a sound casting. He wondered if the author could enlighten him at all as to whether the centrifugal casting of copper had become a definite commercial proposition and was being adopted where applicable.

MR. GEISLER said tuyeres used to be made by forging for they had to be very dense. They were now being made by the centrifugal process as a matter of everyday production and they were at least as good as the forged ones, and very much cheaper. The forging plant had been scrapped. That was a real development.

On this point the CHAIRMAN (Major Miles) mentioned that some time ago his firm had produced in this country copper tuyeres by the centrifugal casting process mentioned in the Paper, but the difficulty was that one had to have continuous production. In this country the demand had not been found sufficient to keep such a plant going.

Blowholes in Centrifugal Castings

MR. S. E. DAWSON suggested that blowholes in castings were due to a chemical reaction between the graphite in the iron and an oxide. This was supported by the fact that if a mould was coated with an easily reducible oxide such as lead oxide, a large number of blowholes were produced and a deposit of lead pellets resulted. Dissolved gases which may be several times the volume of molten iron were eliminated by the centrifugal action at an early stage, but gases produced on the outside of the casting may be trapped if formed after the metal solidified.

With regard to the question of austenitic cast iron raised by Mr. Twigger, it was necessary to have a manganese equivalent of about 12 per cent., obtainable by the use partly of manganese itself together with sufficient nickel to produce suitable softness. In steel where relatively little carbon was present, the equivalent manganese required to retain the austenitic condition was about 16 per cent. Copper which hardened cast iron could be used in place of nickel to a limited amount, say 5 per cent. maximum. This was the basis of his original patent for non-magnetic cast iron taken out in 1920.

MR. GEISLER said the causes of pinholes and blowholes were so numerous that they could talk about them for hours. As to the austenitic iron, it was a fact that with about 3 per cent. carbon in iron from 12 to 14 per cent. manganese was needed to get the desired result.

MR. DAWSON further amplified his point about blowholes by saying that the amount of gas dissolved in cast iron was very great; one could have four or five times the volume of gas to that of the metal dissolved in it. If blowholes were due to that gas they would never be able to cast a pipe. The gas in solution, he claimed, was eliminated by the centrifugal process, and the formation of blowholes was due to the chemical reaction he had mentioned.

Speed played an important part, and the increased speed to which reference had been made gave a thinner layer of metal which set quicker, and, therefore, tended to cause blowholes from the fact that the metal setting trapped the chemically-produced gases, and gave them less chance of being brought to the inside.

Mould Dressings and Blowhole Elimination

MR. F. C. PEARCE, speaking on the same subject, suggested Mr. Dawson's contention could be disproved. One could always get rid of blowholes by making the casting thicker. Mr. Geisler had left speeds where they were—he understood the best speed was still about 1,800 ft. a min.—and he also left dressings where they were. Had he no information about better dressings, cheaper and easier to apply? What was the highest speed he had used? What also was the minimum section thickness of cylinder liners in Germany, and what was the minimum phosphorus content of the casting which should be not more than 0.3 in. in section thickness?

MR. GEISLER replied that the cheapest coating they had was ordinary blacking, and that worked very nicely. As a matter of fact it was not necessary to apply a coating after every casting, since there was always some material left when the mould was stripped. As graphite was very cheap and satisfactory they had not troubled to try anything else.

As to eliminating blowholes by making castings thicker, that was possibly the case, but customers would not always be satisfied with such a remedy. They did not want castings heavier than they need be. The thinnest castings made had been from $\frac{3}{16}$ in. to $\frac{1}{4}$ in. thick, and they had made iron castings, to be hardened subsequently by the nitrogen process, with below 0.1 per cent. of phosphorus.

SPECIALLY-HARD ALLOY CAST IRONS FOR RESISTANCE TO ABRASION

This Paper, by M. M. Hallett and A. B. Everest, printed on page 23 *et seq* of our issue of July 13, was next presented.

MR. R. CHAVY said the authors had drawn attention to the importance of the carbon content of the austenite in determining the structure of white irons of the Ni-Hard type. This factor was without doubt very important, and should be considered in conjunction with the effect of total carbon content, to which attention had been drawn in a Paper presented to the International Congress in 1935.[1]

The experiments reported in that Paper led to the conclusion that if it could be assumed that the constituent (austenite, martensite or troostite) which accompanied the carbides contained approximately the whole of the nickel, then the concentration of nickel in this constituent was progressively higher as the amount of combined carbon was increased. Thus, if for a certain section thickness of casting in a white iron containing about 2.5 per cent. carbon the nickel content necessary to obtain martensite was of the order of 4.5 to 5.0 per cent., then the nickel necessary would only be 3.5 to 4.0 per cent. if the carbon content was raised to 4.0 per cent. Under certain circumstances it might, therefore, be desirable in a casting of given section to take this factor into account and to adjust the content of nickel in proportion to the carbon present.

It was also interesting to note that one could harden some nickel-chromium white irons by air-quenching from 850 to 900 deg. C. in the same way as in quenching grey irons or air-hardening nickel-chromium steels. In this case the content of nickel and chromium was maintained at a lower level than that necessary for obtaining martensite in the "as-cast" state, and the maximum hardness (750 to 850 Vickers) was obtained by quenching in air. These irons should be interesting for castings which were required to be lightly machined, but which in service must possess the greatest possible hardness.

He had similarly studied, in association with Dr. M. Ballay, the oxy-acetylene hard surfacing of steel or iron specimens with a thin layer (0.08-0.2 in. thick) of white iron. A Paper on this subject was presented to the Foundry Congress in Paris in June, 1937.[2] Certain nickel-chromium white irons lent themselves particularly well to deposition. The adherence was excellent and the hardness was equal or even superior to that of certain more expensive alloys actually used for this application. Thus the surface deposited could attain a hardness of 650 to 750 Vickers Brinell, and sometimes one could increase this hardness by air-cooling from 850 to 900 deg. C. up to values of 800 to 850 Vickers.

For irons required for surface repairs, the nickel and chromium contents should be kept quite low (2 to 3 per cent., according to the carbon content), on account of the very high speed of cooling of the deposited metal.

Finally, during the course of these studies it had been found that with relatively low nickel contents (6 to 10 per cent.) and chromium contents of 4 to 6 per cent., one could obtain white irons with a cementite-austenite structure the hardness of which was approximately the same as those of the base irons of the same carbon content, but which had numerous advantages in relation to ordinary white irons:—(1) High resistance to shock, about three times higher than that of the ordinary base iron; (2) high resistance to corrosion by certain acids, in particular hydrochloric acid, and (3) resistance to heat and especially low sensitivity to thermal shock. This last property rendered it possible to envisage the use of these white austenitic irons for applications requiring resistance to wear at very high temperature, such as the cooling elements for cement clinker for example, where the metal must resist at the same time both high temperature and erosion.

[1] Ballay and Chavy. "Special White Cast Irons." Bull. Assoc. Tech. Fond., 1935, ix, December, 366-380.

[2] "Special White Cast Irons and Cupro-Nickels Containing Tin for Building Up by Torch Welding." M. Ballay and R. Chavy. International Foundry Congress, Paris, 1937. Paper C.I. 28.

Alloy Requirements to Form Martensite

In reply the AUTHORS stated that they were aware of the interesting work carried out on white cast irons by Mr. Chavy and Dr. Ballay, in which it was concluded that the carbon content affected the alloy content required to form martensite. This work was, however, carried out over a much wider range of carbon than that studied in the present Paper. In their own work over the restricted carbon range of 2.8 to 3.2 per cent., the authors did not find any evidence of this effect.

They were very interested in Mr. Chavy's experiments with white austenitic cast iron. From their own experience with irons of this type, such as Ni-Resist with 5 per cent. chromium, they could confirm the valuable combination of hardness, corrosion and heat resistance which they possessed.

The authors were aware of the employment of these alloy white irons for hard surfacing, and of the useful contribution to this subject made by Mr. Chavy. While there were cases where a low alloy content was advisable, they believed that there were others where it would be advantageous to keep the nickel content somewhat higher, thus ensuring the presence of a small quantity of austenite which might assist in connection with toughness and wear resistance.

MR. P. A. RUSSELL, B.Sc., found the fact that thicker castings could have a lower alloy content to obtain optimum properties most interesting, for he had always assumed that at least 4 per cent. nickel was needed to produce martensite in a casting.

Did those properties extend to grey cast iron, because there were a large number of castings made with about 2½ per cent. nickel which were produced not to be martensitic as cast, but for heat-treatable iron, and if 2½ per cent. would produce martensite, it was rather surprising, because in his experience such irons were freely machinable.

Mass and Alloy Additions

The AUTHORS agreed that it was not an unfamiliar idea that one required a lower alloy content when the castings were small. The formation of martensite was dependent on the alloy content and rate of cooling. The importance of the rate of cooling was well illustrated by a case in which extremely small single cast piston rings were made. These naturally cooled very quickly and showed appreciable contents of martensite even with ½ per cent. of nickel. With 1 per cent. of nickel they were almost fully martensitic. This clearly showed that as the rate of cooling rose, the alloy content necessary was lowered. The point was possibly rather academic, as such very small castings were not often produced in the foundry. As regards the nickel content required to produce martensite in grey cast iron, that again depended partly on the thickness of section, or, in other words, on the rate of cooling. With the nickel content of 4 per cent., ⅛-in. and ¼-in. sections would be martensitic as cast, but sections of ½ in. or thicker would not be martensitic. A 3 per cent. nickel grey iron was not martensitic in any section down to ⅛ in. These observation confirmed those of Mr. Russell. The reason why a higher nickel content was required in grey iron was partly due to the higher silicon content of the grey iron as compared with that of a white iron, though it was possible that the effect of concentration of alloys in the dendrites mentioned by Mr. Chavy might play a part.

Tube Mill Liners

MR. A. H. GUY (President, S.A. Branch) mentioned that his firm were large manufacturers of white iron, principally tube-mill liners. They had to wear down to ¼ in. before being taken out, having started at 4 in. They used a mixture of white iron and steel, and added 0.5 per cent. manganese merely as a flux which had no effect on the quality of the iron. From 0.4 to 0.7 per cent. of silicon was added to make the metal flow, and they found that if the addition went any higher than that, the metal became grey or mottled and the Brinell hardness dropped from 410 to 280. They also added 0.3 to 0.4 per cent. of chromium, and the result was that they got a Brinell hardness of 410. He mentioned these facts, because his firm had found that any white iron supplied from England for tube mill liners did not give the same life.

In reply to questions by the chairman, MR. GUY mentioned several other irons and steels which had been tried, but as cost was a ruling factor, many had failed on that account in comparison with the iron mentioned.

The AUTHORS expressed themselves as very interested in Mr. Guy's remarks concerning tube mill liners. Mr. Guy had stated, however, that his results were based principally on one test conducted at his works with an experimental set of Ni-Hard liners. Mr. Guy would, no doubt, be the first to admit that with a complicated alloy such as Ni-Hard one could not expect to get the best results from a first trial, and no doubt the record of 60 per cent. increase in life could be further raised. In fact, in service of this type Ni-Hard had in many cases proved an economical proposition, giving a greater life than necessary to compensate for the increased cost.

MR. GUY added that conditions in tube mills were very severe, for liners had to stand up to attrition as well as impact, consequently if the metal was too hard it would crack before it was worn out.

Relative Conversion Power of Elements

MR. S. E. DAWSON asked whether nickel was the principal element in preventing the conversion of austenite to martensite as stated by Dr. Everest, since manganese was twice as strong as nickel, while chromium was one and a half times as effective in this respect. In steel one could use manganese, nickel or chromium in varying proportions, depending on the physical properties required, such as malleability, machinability and resistance to corrosion. This formed the basis of his patent taken out in 1928. In cast iron the higher carbon limited the amount of chromium permissible.

Application to Grey and White Irons

The AUTHORS thought that Mr. Dawson was neglecting the difference between white iron and grey iron. In a grey iron carbon was present as graphite. In the white iron, it was there as carbide, and when one had carbides present the carbide-forming elements were concentrated in those carbides. That applied particularly to chromium and to a lesser extent to manganese. Therefore, as the elements in question were in the carbide they could not be present in the austenite as well, and so had very little effect on the breakdown of the austenite. The effect of chromium might be seen in Table I of the Paper where it was shown that increasing the chromium content from about 1 to 1.8 per cent. (maintaining all conditions the same) had very little effect on the amount of nickel required to form martensite. Attention might also be drawn to the iron containing 4.91 per cent. of chromium and no nickel. This material was sorbitic even in the small ⅜ in. dia. rod, and the hardness of the 2-in. section was hardly any higher than that of a plain iron. It was clear that contrary to the ratio of 1½ to 1 which Mr. Dawson quoted as the relative potency of chromium and of nickel, chromium was actually less than a quarter as powerful as nickel in promoting the formation of martensite in white iron. Similar reasoning could be applied in the case of manganese.

THERMAL CONDUCTIVITY OF HIGH-DUTY AND ALLOY CAST IRONS

DR. DONALDSON next presented his Paper bearing the above title. It has been printed in our June 15 issue.

MR. F. J. COOK (Birmingham) said every foundryman was indebted to Dr. Donaldson for his work in that particular field. Did Dr. Donaldson agree that the amount of combined carbon—also the addition of graphite—had an effect on the results he had obtained of thermal conductivity, and would he include with his Paper, when it was printed, some particulars of these features?

DR. J. W. DONALDSON replied that such information had been given in previous Papers. Graphite did not appear to exert a marked influence except where it affected the denseness of the iron. Combined carbon certainly had an influence, as it had been previously shown that free ferrite was a much better conductor of heat than eutectoid pearlite, owing to the relative conductivities of ferrite and cementite which had been determined as 0.174 and 0.017 respectively.

The Lorenz Constant

MR. M. M. HALLETT said that, taken in conjunction with his earlier publications, the present Paper gave a clear idea of the effect of composition on the thermal conductivity of cast iron, a field of investigation which Dr. Donaldson had made his own. The value of the Paper would have been enhanced if measurements of the electrical conductivity of the bars under test had also been made, even if only at room temperature, as in most laboratories this property was much more convenient to determine, and reliable data regarding the Lorenz constant would enable a reasonably close estimate of the thermal conductivity to be made. Dr. Donaldson might actually have some data on this point which he had not incorporated in the Paper. The values of the Lorenz constant available in the literature could not be regarded as adequate.

One might comment on the presence of 0.54 per cent. chromium in the sample of Ni-Tensyl iron. This material did not normally contain chromium in any appreciable amount. Incidentally, in all three summaries, the nickel and chromium contents of the Ni-Tensyl iron had been inverted.

The Relationship with Carbon Affinity

An outstanding point, which must have struck all metallurgists familiar with the constitution of cast iron, was the manner in which the effect of alloy elements on thermal conductivity was related to their affinity for carbon. Thus chromium, tungsten and manganese raised the conductivity in almost exact proportion to the stability of their carbides, while the graphitising elements, nickel and silicon, lowered the conductivity. In the Paper presented by Dr. Everest and the speaker, an endeavour had been made to show the importance of the carbon content of the austenite on the properties of martensitic white iron. Might it be that those elements forming stable carbides raised the conductivity of an iron by causing the withdrawal of carbon from solution in the ferrite lamellæ of the pearlite, the ferrite presumably being the chief conducting structural phase, and therefore the phase in which one must look for changes to account for variations in conductivity? The relative effects of nickel and silicon, unexpected in view of the considerably greater graphitising power of silicon, might be explained by reference to the greater effect of silicon in precipitating carbon from solution in ferrite. This would raise the conductivity in opposition to the direct influence of silicon in decreasing conductivity as it entered into solution. Light might be thrown on this suggestion by an examination of oil-quenched samples where the degree of dispersion of the carbon would be the same in both cases. Under these conditions the chromium might even lower the conductivity.

In conclusion, he would like to congratulate Dr. Donaldson on adding another link to his interesting chain of investigations on the thermal conductivity of cast iron, a study which was yielding results both of practical and theoretical interest.

DR. DONALDSON said the determination of the Lorenz coefficient for cast iron was certainly very important. He had not made any electrical resistivity determinations on the various cast irons, but he appreciated the value that would be obtained from such work. The temperature range over which thermal conductivity values could be determined was limited due to heating conditions, but such limitations were not imposed on electrical resistivity determinations. If the Lorenz coefficient could be shown to hold for cast iron both at high and low temperatures, it would be possible to obtain the thermal conductivity at high temperatures by determining the electrical resistivity. Such work had still to be carried out on cast iron, and he hoped it would be done in the near future.

He agreed with Mr. Hallett's remarks on the affinity of carbon for such elements as chromium, molybdenum and tungsten, and their influence on thermal conductivity. He was also interested in what Mr. Hallett had said with regard to thermal conductivity determinations at low temperatures, and thought that it was possible such results might be obtained.

Industrial Application of Results

The CHAIRMAN (Major Miles) asked Dr. Donaldson if he could explain in general terms the desirable properties in thermal conductivity due to the advance from low-pressure steam to high-pressure steam and superheated steam and the internal-combustion engine.

DR. DONALDSON said the investigations were initiated many years ago in connection with the construction of large internal-combustion engines in order to determine which cast irons were most suitable for cylinder liners and piston heads. Aluminium alloys, which had high thermal conductivities and which were used in motor vehicle and aircraft engines, were not used in this type of construction to any marked extent. It was essential to use cast iron having good mechanical properties, high resistance to growth at elevated temperatures and as high a thermal conductivity as possible consistent with the other properties. There were also certain other applications, particularly in turbine and valve construction and in furnace construction, where the value of this constant for cast iron, and particularly for high-duty and heat-resisting cast irons, was of importance.

DEFECTS IN ELECTRICALLY-MELTED CHILLED ROLLS

The last Paper to be presented was by DR. F. BONDI. It is printed elsewhere in this issue.

At the conclusion of this Paper, which was read in Italian, the CHAIRMAN (Major Miles) remarked that, due to the fuel position, and for other reasons, the electric furnace was more extensively used in Italy than was the case in this country, for what one would regard as a cheaper range of products.

The Explosion Mystery

MR. F. J. COOK (Past-President of the Institute of British Foundrymen) said one of the outstanding points of the Paper for the ordinary foundryman was the prominence given to explosions during pourings. Although explosions did happen, they were not of such frequency as to be mentioned in a Paper. Was it to be understood that for some reason, electrically-melted iron was more prone to explosions than ordinary furnace-melted iron? If so, to what was it attributed, because in a properly poured mould one would not expect to have a greater amount of explosions than under ordinary furnace conditions?

Was there some quality of electrically-melted iron that caused those explosions?

DR. BONDI replied there was no particular condition, but it was dependent on the proper preparation of the mould. Iron melted in an electric furnace could be melted at the exact temperature required. One could get superheated iron, but for pouring one had to wait until it was in proper condition.

Pouring Temperatures

MR. J. ROXBURGH (Sheffield) complimented Dr. Bondi on his Paper and thanked him for bringing the subject before them. He had given a temperature of from 1,150 to 1,190 deg. C. for casting the rolls described. That was quite different from English temperatures, which ranged from about 1,230 to 1,270 deg. C. The former range seemed to be a very low casting temperature. Another point of interest was the question of running, and he would like to know the relation of the cross-sectional area of the ingate to that of the downgate, which of course really governed the speed of running.

Another important point was the blacking used, which Dr. Bondi said should be applied to the chills with the maximum uniformity. Could he indicate the actual thickness of the blacking which was applied? On that subject, too, there was a further point. Dr. Bondi said that when applying the blacking the chills were at a temperature of 300 deg. C. That seemed rather a high temperature at which to apply the blacking, as he personally would be afraid of boiling, and difficulty in making the blacking adhere to the chill.

With regard to the composition of the chills, what material was used? Dr. Bondi had said it should be very dense and as low as possible in silicon and phosphorus. Could he say what material was actually used? Could he tell them the sulphur content of the iron from the electric furnace used for the chilled rolls?

Finally, what control was imposed to ascertain the depth of chill shown by the chill test? Did he get much loss from the chill test to the actual casting?

Low Casting Temperatures

DR. BONDI, in reply, said the temperature of pouring with an electric furnace was a matter of practice. The temperature of 1,190 deg. C. or a maximum of 1,200 deg. C. was what they used for their chilled rolls because they found that pouring at higher temperatures caused many difficulties through the rolls cracking and from pinholes.

As to blacking thickness, they applied it with a spray gun. They used not only a trade blacking with sodium silicate, but mixed with it a good quality of high-refractory (about one-third) blacking. They heated the chills up to 300 deg. C. for applying the blacking, because at that temperature it was instantly dried and they could get the right thickness. The layer was about the thickness of an eggshell, and on the underside of the chills about double that thickness. That was to prevent the hot iron running on the chills from attacking it and causing surface trouble.

When melting in an electric furnace, sulphur was of no importance because it could be as low as they wanted. The figures were about 0.012 per cent. or lower if necessary.

As to the differences of the chill test, they allowed for 10 mm. on the chill, which checked up with 5 mm. of contraction and 5 mm. for the cutting of the chill.

Composition and Making of Chills

The chills were made by charging up equal quantities of the chill and a good hematite iron. There was a minimum of manganese (about 0.5 per cent.) and sulphur, whilst the phosphorus was very low; the carbon was about 3 per cent. and the whole was melted by cupola with a silicon content of about 2.5 per cent.

As to the size of runners and gate, these were adjusted in relation to the diameter of the roll. For the little rolls of about 300 to 350 mm. diameter, they used a runner of about 50-mm. section so as to cast rapidly. For a roll of about 500 to 550 mm. diameter and 1,400 mm.

(*Concluded on page 59.*)

The Open-Hearth Furnace for Melting Malleable Cast Iron*

NOTES ON THE DESIGN AND OPERATION

By G. R. SHOTTON†

In considering the open-hearth furnace as a medium for melting malleable cast iron, it is not the intention of the author to draw a comparison with other better-known types of melting furnaces, but rather to set out his accumulated experiences of the design and operation of the open-hearth furnace.

In Great Britain, the air furnace, rotary furnace, cupola and, to a lesser extent, the electric furnace, are the most popular melting furnaces for the production of malleable cast iron. The open-hearth furnace has only been adopted in two or three plants, and the results obtained in these plants appear to have varied considerably.

Each of the melting furnaces mentioned above has certain advantages, and with the exception of the open-hearth furnace, there is a considerable amount of published data available regarding their construction and operation. In the case of the open-hearth furnace, however, there are few data available on its operation for the production of malleable cast iron, although it is well known as a melting medium for the production of steel.

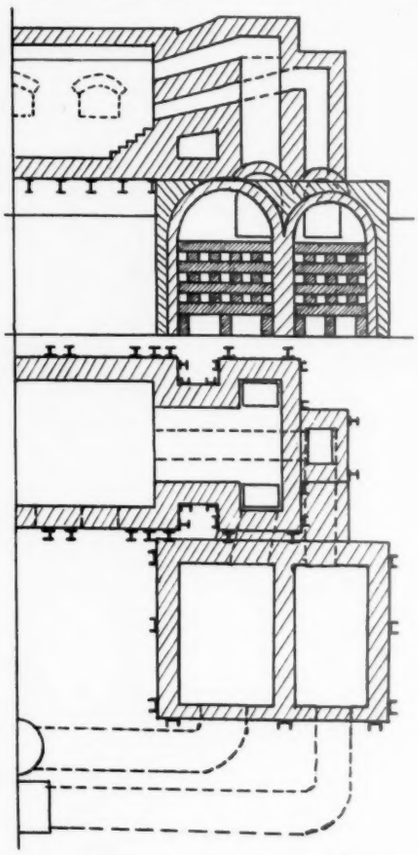

FIG. 1.—DIAGRAM OF OPEN-HEARTH FURNACE.

Undoubtedly, the high initial cost of installing an open-hearth furnace is the most serious deterrent to its more general adoption in malleable foundries, though it appears probable that a wider knowledge of the results obtainable might lead to the more general use of this type of furnace. While the capital cost is high in comparison with other types of melting furnaces, it is quite economical in operation, provided it can be run at a reasonable capacity.

Before considering the more important features of design and operating data, it is advisable to explain the basis on which the data have been obtained. The notes on design, together with all the operating data given, have been obtained on a new furnace installation with a capacity of 15 tons. This furnace has been installed to cope with the metal supply for foundry extensions which were not complete when this Paper was prepared. Consequently, the furnace has been running below capacity, and there is no doubt that a further reduction in fuel costs will be obtained when operating on a full metal output. The furnace has now been operating for several months, and the operating data given are extracted from the actual daily records over this period.

As no figures are yet available for refractory costs, those given in this Paper are based on results obtained over the past three years on an 8-ton open-hearth furnace of similar design, which has now been superseded by the new 15-ton furnace. There is no doubt that the larger furnace will show a saving in refractory cost, when expressed in terms of cost per ton of metal melted.

Furnace Design

The general design of an open-hearth furnace is well known and does not call for further description. Fig. 1 is a diagram showing the general lay-out of the furnace and regenerators. Certain features of the design may markedly affect the efficiency of the furnace, and these may not be so generally appreciated. In discussing the most important details of design, it should be borne in mind that the same remarks will not necessarily apply to the large open-hearth furnaces of 50 to 200 tons capacity which are used for the production of steel. The following notes on design are of an essentially general character, but where actual figures are given they will relate to the 15-ton furnace on which the operating data were obtained.

The gas- and air-ports are shown in Fig. 1, which gives a half-elevation and half-plan of the furnace body, gas- and air-ports, and regenerators. The gas-port, which is the lower one, is approximately 14 in. wide by 9 in. high where the gas enters the furnace body. The air-port above is about 12 in. high and extends almost the full width of the furnace, so that a blanket of air effectively keeps the flame well down on the bed of the furnace.

If the air-port is too small, difficulty may be experienced in keeping the flame down on the bed of the furnace, and this is essential, since the furnace crown would be quickly melted down if the flame were allowed to impinge directly on it. For the same reason, the slope on the ports is highly important. The gas-port is made about 10 ft. in length in order to give direction to the gas flow, and is built with a slope of 1 in 4, *i.e.*, the level of the port rises 1 ft. in every 4 ft. of length. This length, combined with the slope of the port, will effectively direct the gas flame down on to the bed of the furnace. If too steep a slope is employed, the flame will strike the furnace bed too sharply, and eddies of flame may strike upwards to the crown, which would be melted down in a few days under such conditions. On the other hand, insufficient slope on the gas-ports would result in the flame developing too high in the furnace, and the crown would again suffer.

The air-port is sloped at approximately the same angle as the gas-port, but does not need to be so long. In the modern type of furnace, the air-port has two down-takes, and the gas-port passes through and beyond these and has a single down-take. This construction allows easy access to the port and down-take, and so facilitates the carrying out of minor repairs to the ports, etc. At the same time it enables the gas-port to be considerably longer than would be the case if its down-take was built between the furnace body and the air down-take, as was the case in the older designs.

Fig. 2 is a photograph of one end of the furnace, showing the slope on the crown of the ports, and the general construction of the port block and down-takes, the whole being well braced with buck-staves and tie-rods. It is good practice to construct an air space between the furnace body and the gas down-take as shown in Fig. 1, as this helps to cool the brickwork adjacent to the ports and down-takes and so prevents serious erosion of the lining.

Furnace Body

The body of the furnace is rectangular in shape, and to avoid excessive wear on the port noses, while allowing full development of the flame, the length of the bed should be about two and a half times the width, for a given capacity of furnace. It should be noted that the average depth of molten metal is usually appreciably less in proportion to the furnace capacity than is the case in the open-hearth furnace operating for steel castings. This facilitates rapid superheating of the molten metal to meet foundry requirements.

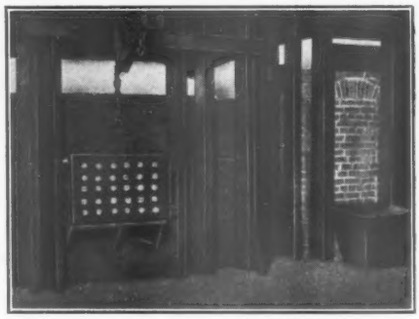

FIG. 2.—END OF FURNACE, SHOWING PORT BLOCK.

The crown of the furnace is arched, with about 12 in. spring from the side wall to the centre of the crown. The level of the crown may be raised a few inches just in front of the port block to allow in part for the rapid expansion of the gases in the furnace. This practice also helps to guard against the flame being deflected against the crown while the cold charge is massed high on the furnace bed.

A general view of the furnace, together with the charging stage and the entrance to the valve pit, is shown in Fig. 3, which also shows the three working doors through which the metal is charged and manipulated, the molten metal being tapped from the other side of the furnace.

Regenerators

The intake flues leading from the bottom of the down-takes to the gas and air regenerators should be of ample size, and are lined with silica bricks. The level of these intake flues is approximately level with the top of the regenerator brickwork, so that the exhaust gases sweep right across the top of the regenerators and pass downwards throughout the whole area of the "honeycomb" brickwork, which is of good-quality firebrick.

Since the regenerators are required to maintain a temperature of between 900 and 1,000

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

† Works manager, Shotton Bros., Limited, Oldbury.

deg. C., it is important that they be built sufficiently large to ensure a reserve of heat which will not be seriously depleted by the incoming gas and air during the 15-min. interval between valve reversals. In the 15-ton furnace now under consideration, the temperature of the regenerators reaches about 960 deg. C., and shows a temperature drop of only about 60 to 90 deg. C. on each reversal of gas and air flow.

Reversing Valves

There are many types of reversing valves giving good service in open-hearth furnaces. The essential requirement of a good valve is resistance to distortion, since it will be realised that the exhaust gases are still very hot when they pass through the valves to the stack flue, and the valve must be of robust construction if severe distortion is to be avoided.

The air reversing valve is usually of the simple butterfly type, and this will give efficient and continuous service for many years. A water-sealed valve is preferable for the gas reversing valve. This will effectively prevent leakage of gas into the stack flue and at the same time will reduce distortion on the valve plates. Since there is considerable evaporation of the water, a ball valve should be fitted to maintain a constant water level.

FIG. 3.—GENERAL VIEW OF FURNACE AND CHARGING STAGE.

Maintenance of the Furnace

The open-hearth furnace can be operated continuously for several months without any lengthy stoppage for repairs. Generally speaking, the life of the brickwork is increased when the furnace is maintained continuously at a temperature approximating to melting conditions. This is effected by keeping the furnace dampered down between melting periods (*i.e.*, during the night and at week-ends), and a slow gas supply is put through the furnace during these periods so that the temperature of the furnace body and the regenerators does not fall appreciably. This is dealt with later when discussing fuel consumption.

A "swill-heat" is usually carried out at the week-end to keep the bed in good condition. That is to say, limestone is spread over the bed and around the breasts of the furnace, and the furnace is operated at melting temperature for four to six hours. The limestone attacks the silica sand of the bed and forms a lime-silica slag. After tapping this slag, the furnaceman cuts off any portions of the bed which have been undermined, so that the level of the bed is appreciably lowered. After "drying-up" the bed with wet silica sand, dry silica sand is spread thinly over to re-form the bed, and "fritted" on. This procedure is essential, since the height of the bed tends to rise during the course of a week's melting, and any small accumulations of slag or iron which have been absorbed in the bed during the week are undermined and tapped with the slag resulting from the "swill-heat." The cost of the fuel used for this "swill-heat" must, of course, be taken into consideration when taking out figures for fuel consumption.

Very few repairs to the brickwork become necessary during the working life of the furnace. The working life varies according to operating conditions, but such repairs as are necessary can usually be carried out at fixed holiday periods.

The life of the port blocks, particularly the noses of the ports, is the main factor affecting repair periods. Under normal conditions, the port blocks must be rebuilt at intervals of four to six months, and this work is usually carried out during two or three of the normal Bank-holiday periods in each year, according to the amount of wear apparent just prior to a particular holiday period. While repairs to the port blocks, etc., are being carried out, advantage is taken of the opportunity afforded to empty the regenerators and clean the bricks before replacing them. The brickwork of the regenerators tends to "fur up" after some months, but this work can usually be left until repairs to the port blocks, etc., become necessary.

The side walls and crown of the furnace will usually last for a period of twelve to twenty-four months before it becomes necessary to rebuild them. Their working life largely depends on the maintenance of the port blocks in good condition, so that the flame does not impinge directly on the brickwork of the side walls and crown. A life of approximately two years has been obtained under good working conditions, apart from minor repairs to the door jambs, etc.

The total cost of repairs to brickwork, and the cost of silica sand and plastic refractories for the tapping hole, etc., will be more or less independent of actual tonnage of metal melted. While the 15-ton furnace under consideration in this Paper has not been operating for a sufficient time to afford any reliable cost figures for refractories, etc., the data obtained from a similar 8-ton furnace over the past few years may afford an approximate comparison. In the opinion of the author, the 15-ton furnace, if operated at reasonable capacity, should show an appreciable saving over the figures now quoted.

The maintenance costs on the 8-ton capacity furnace, taken over a period of approximately three years, during which period eleven heats averaging 6 to 8 tons each were melted in each working week, are as follow:—

Silica sand and plastic refractories for maintenance of furnace bed and tapping hole ... 4d. per ton of metal melted.

Silica bricks, silica cement, firebricks, etc., used on repair work, rebuilding, etc. ..... 1s. 7d. per ton of metal melted.

The total refractories cost therefore ..... 1s. 11d. per ton of metal melted.

During the same period, fluxes used when melting and for "swill-heats," etc., average approximately 4½d. per ton of metal melted.

The total cost of all refractories taken over periods of two or three years remains constant, but the cost per ton of metal melted will naturally vary in proportion to the output of metal from the furnace.

It is fully expected that the total refractories cost taken over a period on the 15-ton furnace will not exceed by a very great amount the total refractory cost on the 8-ton furnace over a similar period. It thus follows that if the larger furnace is operated at a reasonable capacity, a large reduction in refractories cost per ton of metal melted should be obtained, and it would appear reasonable to expect that on the basis of 10-ton heats as an average charge (*i.e.*, approximately 110 tons output of molten metal per week) the total cost of all refractories used would be reduced to a figure of about 1s. 7d. per ton of metal melted. The cost of fluxing material should show a slight decrease, and should not exceed 4d. per ton of metal melted.

(To be continued.)

Recent Foundry Developments

(Concluded from page 57.)

they used a runner of about 60 mm. and the nozzle of the ladle was about 50 mm. Such rolls were poured in from 30 to 35 secs. The relation between the runner and the intake and the runner and the neck was about one to three. The runner was circular and the intake was rectangular because it was tangential to the roll.

Influence of Melting Process on Chill

MR. R. CHAVY (Paris) asked if any preparatory experiments were made to see if the depth of the chill was the same for an iron made in the cupola and an iron made in the electric furnace. From his experience it appeared that the chill was deeper when cast iron was melted in the electric furnace.

DR. BONDI agreed that it was so. With the same compositions they had a chill of about 4 or 5 mm. higher with the electric furnace than with the cupola, and the metal was denser in the chill section than in the core section.

The CHAIRMAN (Major Miles) thanked Dr. Bondi for his very interesting Paper which had prompted so full a discussion, and Dr. Vanzetti and the Federazione Nazionale for allowing the Paper to be presented.

The Presidential Address

In his Presidential Address to the recent International Foundry Congress, in London, Mr. W. B. Lake, J.P., made reference to the first cast of steel ever made in a pulverised-fuel rotary furnace. In this connection, Mr. Theret, the chairman of the Etablissements Vve G. Theret, writes us that the first experimental cast was made in their Sesci furnace on July 20, 1931. The steel contained 0.164 per cent. carbon and gave 26 tons tensile associated with 28 per cent. elongation.

Defects in Electrically-Melted Chilled Rolls*

By Dr.-Ing. FRANCO BONDI

(*Presented on behalf of Federazione Nazionale Fascista degli Industriali Metallurgici*)

For various reasons, the casting of chilled rolls melted in the electric furnace is certainly neither common nor widespread. The most obvious of these reasons is economic in character, in view of the appreciable cost of erection and operation which this excellent method of melting involves in most countries. At the Acciaierie e Ferriere Lombarde Falck of Milan, particularly favourable conditions have made it possible first to carry out experiments and then to cast normally chilled rolls melted in the electric furnace.

The advantages offered by this method of melting are very important and certainly superior to the previous methods. The outstanding advantage is the possibility of maintaining unvarying composition which is always controllable during the operation, either by chemical analysis or by testing the variations of the hardness of bath samples.

This control also ensures perfect homogeneity of the bath, a very important matter when a number of rolls of the same type have to be cast from the same melt. Carbon, manganese, silicon and phosphorus are constant and similar from roll to roll. There is also the advantage of rapid melting and rapid working-down, so that in a 3-ton furnace it is possible to prepare a melt in three or four hours, including the charging time.

It enables a considerable percentage of steel to be incorporated without giving rise to any difficulties during melting. Another important advantage is the control of the temperature in the various stages of melting, thus permitting rapid melting at high temperatures of the different sorts of scrap contained in the charge, whilst fresh pig, expensive and easily liquefied, may be melted in a bath already prepared by charging the pig at a second stage without subjecting it excessively to the severity of the high temperature of the arc.

Further advantages are the exceptional ease whereby samples can be taken at any stage of melting, and the facility whereby it is possible to make corrections, by reason of the structural nature of the electric furnace. A disadvantage —which, however, is not always confirmed—is certainly to be found in the pressure and high temperature attained in the vicinity of the electric arc. This appears to have the disadvantageous effect of destroying the particular qualities of the special irons which make up the charge, or "burning" them, as is said in foundry jargon.

This phenomenon, which is not always confirmed in practice, would explain certain cases of lack of homogeneity and certain defective rolls found in the machine shop and rolling mill, on account of brittle material. Occurrences of this kind can nearly always be avoided by cautious and prudent operation of the furnace, but it is certain that melts carried out in direct arc furnaces of the Héroult type, and in arc resistance furnaces of the Bassanese type, have shown that the latter type is more suitable and rational, also on account of the lower heat to which the essential constituent elements of the metal, particularly the silicon, are subjected. A type of furnace which the author has not tried for melts of this kind, but which ought to give good results, is the indirect arc or radiant type recently adopted in foundry practice.

The melting operation does not offer any appreciable difficulties, and the metallurgical operations succeed one another much more simply and smoothly with regard to the steel incorporated in the charge.

The charges, which are selected and prearranged, are made by first introducing the scrap and steel, if any, whilst the pig is charged later into the molten bath. It is thus possible to apply the maximum power initially, thus appreciably gaining time in melting. A lightly-carburised lime slag is maintained on the molten bath.

When the slag is formed, samples are taken, the current being reduced to about half the original amperage, so that the bath is maintained at a temperature between 1,250 and 1,300 deg. C. This very important control is effected by continuous observation of the temperature by means of an optical pyrometer. Any rise in temperature is corrected by switching off the current and spreading fluorspar on the slag. The hardness is then checked, any irregularities being corrected by the addition of ferro-silicon and special pig.

If the bath will not take the addition of ferro-silicon on account of the presence of a slag which is too basic, the slag is entirely renewed and the trouble will then disappear. As a rule, only two or three samples have to be taken for bringing the melt into condition, the laboratory ascertaining in the meantime the variations in the carbon, silicon and manganese. When these three elements and the chill test are in agreement and the temperature is satisfactory, the charge is ready for pouring. This is usually carried out by means of a bottom-pouring ladle, which has the great advantage of eliminating any danger of slag inclusions, the only precaution taken being to employ a very large nozzle of 50 to 60 mm. (2 to 2.4 in.), and sometimes even 70 mm. (2¾ in.), according to the diameter of the roll, so that pouring will be very rapid.

The pouring temperature is accurately controlled either by means of optical instruments or by means of appropriate technical devices, and is maintained between the limits of 1,150 and 1,190 deg. C. The average power consumption per metric ton is about 750 kw.-hrs. The bath samples are 190 by 135 by 22 mm. (7.5 by 5.25 by 0.8 in.), cast in dry loam placed on an iron plate. The moulding of these rolls does not offer any special features, except that the greatest care is taken in designing the moulding boxes, so as to facilitate the accurate assembling of the pouring gates and chills and the rapid removal of the gases from the mould.

Having outlined the melting processes, it is now proposed to discuss the general defects which have been encountered in the course of several years of production. These defects, although not peculiar to electric-furnace melting, are those which have been more especially encountered when employing this method. Generally speaking, it must be said that rolls are never cast with a greater body-length than 1,400 mm. (4 ft. 7 in.) nor a diameter exceeding 560 mm. (22 in.) (see Figs. 1 and 2).

These defects may be set out as follow:—(1) Explosions during pouring; (2) cracking; (3) cavities and surface flaws; (4) brittle necks, and (5) eccentricity and variation in hardness.

It is proposed to consider what are the real and probable causes of each of them and how it is possible to provide a remedy for ensuring the production of sound castings in this difficult branch of foundry practice—an endeavour which requires all the art of the foundryman, who is confronted with multiple and various factors which are not always clearly identifiable.

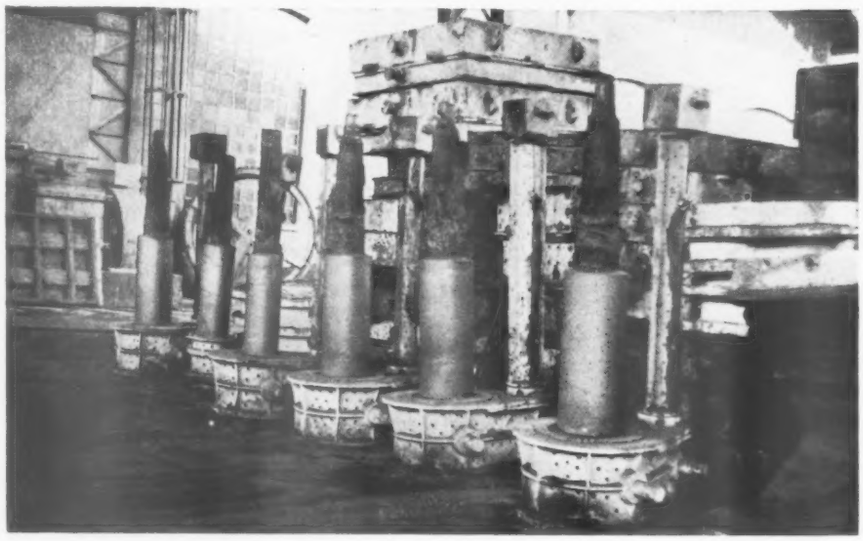

FIG. 1.

EXPLOSIONS DURING POURING

This occurrence, fortunately not very common in a well-conducted shop, is very harmful and dangerous, and always takes place at the commencement of pouring, when the iron has filled only the lower neck of the roll or a little more. At this moment, one or more explosions project the molten iron from the pouring gate with such violence that the iron is thrown to a height of several yards. This phenomenon sometimes occurs when the mould is completely full, when it produces ferrostatic pressure in the metal. In this case it is less violent, and is accompanied simply by bubbling on the surface of the metal in the pouring gate and less violent spurting of the metal.

When this takes place, it is useless to continue pouring. In nine cases out of ten, it is certain that the roll will be defective. In fact, after stripping, the roll exhibits numerous blackened surface flaws to a depth of up to several millimetres which congregate more especially along the lower third part of the roll. Some of these flaws are situated at a considerable depth below

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

undermined, so that the level of the bed is appreciably lowered. After "drying-up" the afford an approximate comparison. In the bon and gave 26 tons tensile associated with 15 opinion of the author, the 15-ton furnace, if per cent. elongation.

the surface, so that even if the first blistered layer is removed by turning, the defect is not eliminated and the roll has to be rejected.

The defect is caused by the difficulty of rapidly eliminating the gas from the mould and sometimes from the coating of blacking on the chill, either through the loam by virtue of its natural perviousness and the means provided for promoting the latter, or through the surface of contact between the loam and the chill. The iron entering the loam mould of the neck, and rapidly filling it, may produce a violent liberation of gas. In the majority of cases it is water vapour, which not finding an easy exit through the mould, because the metal has already arrived at the chill, endeavours on account of its sudden increase in volume to seek a rapid exit through the molten iron, carrying the latter along and projecting it to the exterior.

Causes. (1) Insufficiently permeable loam; (2) insufficient venting, not exactly conforming with predetermined arrangements; (3) blacking contains too much volatile matter; (4) insufficient drying; (5) irrational cooling devices for the

FIG. 2.

necks not permitting satisfactory ventilation of the lower boxes, and (6) chills not hot enough.

Remedies.—Accurate control of the moulding loam which should possess the optimum properties, failing which its use should not be permitted. Close consideration of the venting system for the removal of gas either through the mould, or through the box, in which numerous suitable holes should be provided, or through the joints between the mould and chill. Meticulous and careful consideration of this important part of the preparation of a roll can never be over-emphasised, and experience alone, in reference to the type of roll cast in each case, will indicate the correct steps to be taken.

With regard to blacking which contains an excessive amount of volatile matter, every foundryman will be familiar with the harm which this may cause. In this special case, therefore, the greatest attention should be paid to the quality of this material. Generally speaking, the amount of volatile matter should not exceed 1.5 per cent. of the principal ingredient employed, usually graphite.

Passing to the question of insufficient drying, the author would emphasise the more important factor of these defects, since even if all the other precautions are taken, they are vitiated by the presence of even a very small amount of moisture in the mould. It is necessary not only to control the temperature of the drying stove and the time of drying, but the stove should also be rationally constructed to permit replenishing of the air for removing the vapour. The provision of forced draught effects a saving in fuel and ensures uniform temperatures. It is preferable to remove the moulds just before pouring, so that they will still be warm at the time this operation is effected. Lastly, it is advisable to provide moulding boxes of such a character that the moisture evaporated when the metal enters the mould cannot collect in them.

Sometimes, because of design and working conditions, the necks have to be particularly dense and compact, and in such a case, apart from special blending and composition of the iron, it is possible to employ chills placed in the mould so that they are covered to a depth of a few millimetres with loam, sufficient to prevent them exerting a direct hardening effect. Of course, this mass of metal is an obstacle to the removal of the gases, and the disadvantage may be lessened by providing numerous vents. If the chills be not sufficiently hot, particularly in winter, moisture may condense on them, and, if not noticed and removed in time, this may have disastrous consequences.

CRACKING

This defect is one of the commonest and most feared in the production of rolls. The cracks appear in a wide variety of forms, longitudinal and transverse, and may extend over the entire length of the body of the roll or only over a part, on the edges and centre and finally on the necks (Figs. 3 and 4).

The causes are numerous and often not very clear, but, generally speaking, they may be classified as follow:—(1) Moulding defects; (2) defective pouring; and (3) metal of unsuitable composition.

Moulding Defects

A common cause is the joints between boxes and chills being inadequately sealed. The iron enters the interstices formed and produces a small fin sufficient to cause horizontal cracks due to irregular shrinkage (Fig. 4). Cracks may also be formed along the joint between two chills, due to the joint being insufficiently tight, and to the more intense cooling along this line, or else because of the temperature of the two parts not being the same, and resulting in different rates of cooling in the two sections of the roll.

These defects may be obviated by sealing well all the joints either between the chills and the loam or between the chills, and by taking care to see that the latter are at the same temperature prior to pouring.

Blacking may not be correlated with the cooling effect required from the chills, or be properly applied. With reference to the first case, blacking should have an insulating effect, *i.e.*, in addition to preventing the iron from sticking to the face of the chill, and to providing the casting with a fine surface, the blacking should principally also regulate the rate of formation of the hardened layer, so that the latter is not completely solidified at the moment shrinkage commences, and the inner grey iron sets, producing very high pressures on its expansion. If the chilled layer is still in a condition of relative plasticity, it will "give" to some extent without rupturing, and the surface will remain sound, but if on the contrary it is already solid, it cannot yield and will crack, as is often the case.

The observation and study of this delicate and important factor has led the author to turn his attention to this last circumstance in an attempt to impart to the blacking the quality which will combine its insulating property with that of producing a good surface. Normally, in fact, it is usual to provide the previously-heated chills with one or more coatings of a mixture composed mainly of graphite and bonding materials. Experience has resulted in the creation of a mixture of insulating material, which is highly refractory (above 1,700 deg. C.), made up of best plastic clay mixed with graphite in definite proportions.

This mixture is applied to the chills with the maximum uniformity and with the desired thick-

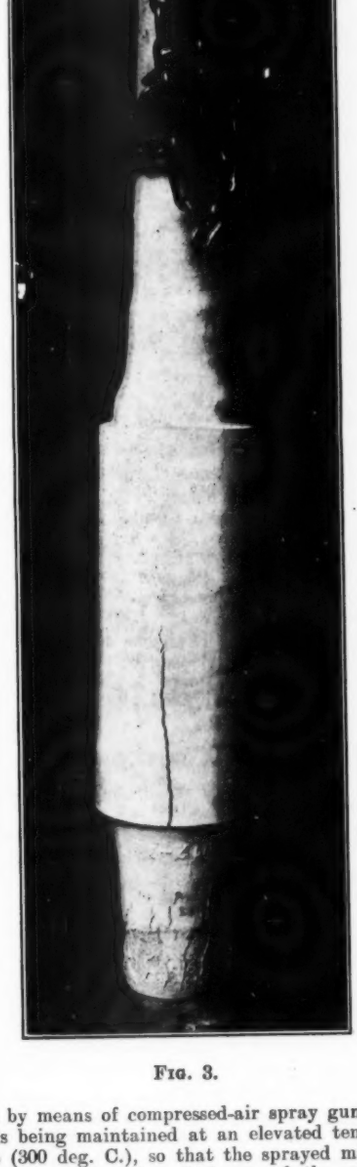

FIG. 3.

ness by means of compressed-air spray guns, the chills being maintained at an elevated temperature (300 deg. C.), so that the sprayed mixture dries instantly. The thickness of the coating produced may be so regulated as to insulate more the parts which are longer in contact with the cast metal, thus attaining the desired uniformity of cooling. In this way, the formation of cracks on the body of the rolls is almost completely avoided, and rolls of very fine appearance are produced (Figs. 1 and 2).

Cracks on the necks, generally the upper one, are attributable more to defective design than to moulding defects. Such cracks, in fact, occur if definite conditions of proportion in the junction with the body are not observed, in accord-

D

ance with the requirement that this junction should be very gradual. Insufficiently rammed zones in the mould may also produce swellings on the neck, which has shrunk differently from the body of the roll, giving rise to cracks.

Improper Pouring Conditions

A contributory factor in this case is badly-designed pouring gates, that is to say, too small to fill the mould at the desired rate. In this case, as the formation of the chilled layer is not homogeneous, vertical fissures are formed on account of the different effect which the pressure of the iron produces in the interior of the first chill, due to the weight of the iron, and also due to the increase in volume caused by the precipitation of graphite.

In this case, it is necessary to increase the diameter of the gates, so that the layer skin is formed practically at the same time throughout the entire height of the body of the roll and thus reacts uniformly to the internal stresses. This disadvantage occurs solely in rolls of small dimensions.

Moulds not Perfectly Vertical.—In this case, it is likely that vertical cracks will be formed in the lower part of the roll, along the generatrix which is most out of the vertical.

Excessively Slow Pouring.—An essential principle of the production of these castings is that they should always be poured rather quickly, because this ensures the ideal conditions for uniform cooling.

Excessively Hot Pouring.—It is necessary to pour rather cold at a temperature between 1,150 and 1,190 deg. C. The accurate control of this is indispensable, whatever be the method adopted. Pouring as cold and as rapidly as possible is the best guarantee of a good result.

Composition of the Metal

In the electric furnace, the composition of the charge is not of essential importance in regard to cracking, provided certain precautions concerning the rise in temperature are observed, as emphasised at the commencement of this Paper. The only really dangerous element is the manganese, of which it is preferable to maintain a content of not greater than 0.40 per cent. Practical observations in numerous cases have shown that if this figure be exceeded, the increase in rigidity which this element imparts to the iron, especially in the chilled zone, may cause cracking.

CAVITIES AND SURFACE FLAWS

The name describes these flaws. They are generally small cavities with an oxidised surface, having a diameter not exceeding several millimetres and a depth which may attain as much as several centimetres. The most dangerous are those designated "pinholing," which, although they may be of small diameter, extend to a considerable depth, so that when the roll is turned on the lathe, the cavities do not disappear, leaving to some extent a trace which, however small, causes the rejection of the roll.

The causes are almost always attributable to defective moulds and rarely to defects of the metal, since in the electric furnace the phosphorus content is always certain to be below 0.10 per cent., thus safeguarding against any liquation of phosphide eutectic.

They may be:—Impermeable loam; insufficient or badly arranged venting; insufficient drying; badly distributed blacking; insufficient blacking; pouring gates too small; pouring temperature too high; chills too cold, in poor condition and insufficiently polished or cleaned.

The remedies are immediately suggested by these causes. Impermeable loam, by retarding the escape of gas at the moment of pouring, causes the formation of bubbles which sometimes merely settle on the lower surfaces of the chills, while at other times, as has been noted, they produce explosions with much more serious consequences. Inadequate venting may also have the same result. In both cases, close control in the preparation of the loam and moulding obviates all these disadvantages.

Insufficient drying, as is natural, produces conditions which favour defects. This has been emphasised and its more serious consequences discussed when referring to the explosions which occur during pouring.

Badly distributed blacking, especially on the lower portion of the chills, where the incoming hot metal impinges most strongly, may give rise to this defect. If there is insufficient blacking, the latter does not afford enough protection, the metal is partly attacked and there is erosion with the formation of characteristic pinhole defect. If the blacking is too abundant, it is carried by the flow of metal towards the upper part of the roll body, leaving a characteristic spiral trace following the gyratory movement of the iron in the form of striations, along which the excess of graphite is deposited, and numerous small blisters which, however, are generally of little importance (Fig. 4). The correct thickness will be determined by experiment in each particular case, in accordance with the mass and dimensions of the rolls.

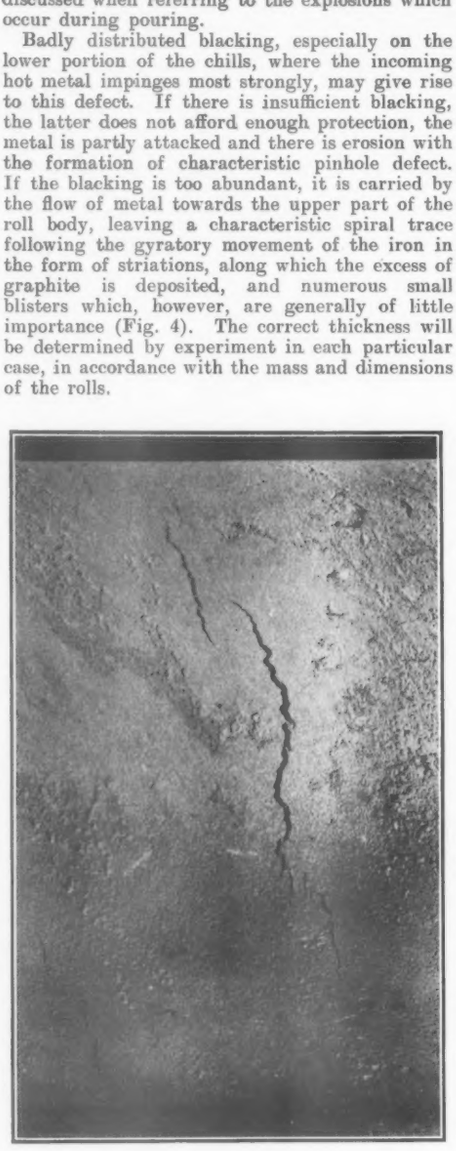

FIG. 4.

The importance of the composition of the blacking should not be overlooked. Excess of graphite, inadequate organic binder or too much clay are also causes of defects. In point of fact, much graphite, especially if not of good quality, causes an evolution of gas which cannot always be eliminated and is the principal cause of pitting. The same applies to organic binders.

In the case of rolls having a rather high silicon content, when there is an excess of clay in the blacking, silicates are formed during pouring with the evolution of gas which remains imprisoned in the skin of the roll. It is possible to produce the best blacking while dispensing completely with organic binders, such as dextrin, molasses, starch, etc. Organic binders may be replaced by inorganic binders, such as refractory clay or bentonites suspended in Na_2SiO_4, without diminishing the adhesive and insulating properties, but on the contrary improving them in some respects. Everything depends upon the correct proportion between clay and graphite and upon the correct preparation. The best practice is to allow the mixture to stand for some days before it is filtered and used.

Gates of excessively small diameter, resulting in the lower parts being heated to a greater extent, may produce erosion and cavities. The same applies to a greater extent when the pouring temperature is too high. The effect of the above two causes is still greater when the chill, through long use, has in part peeled or become otherwise defective, because at these points erosion will be more marked and the iron will attack the walls.

It is advisable, therefore, to insist that the chill is in a perfect condition before applying the blacking. Any defects which are not serious may be repaired with cements, or if they are more extensive by means of electric welding, the surface being afterwards smoothed with a portable grinding wheel. It is thus possible to extend the life of a chill by several castings.

Another rather important factor to be observed is that the inner surface of the chill should be completely free from oxide which, even if covered with blacking, will generate gas in some form. For this purpose, thorough treatment with a portable grinding wheel and a rotary steel brush will afford the maximum guarantee, at the same time dispensing with the tedious method formerly employed, in which the whole of the inner surface was treated manually with a piece of an old emery grinding wheel.

BRITTLE NECKS

This condition arises when the iron is not compact, but includes graphitic patches—a condition ill-adapted to resist wear during rolling and liable to break under load. The cause of this defect may almost always be attributed to an excessively high carbon content. The defect tends to disappear when the carbon content is 3.2 to 3.4 per cent. and appears upon an increase in these values. Sometimes, owing to particular requirements dependent upon the dimensions of the roll, that is to say the ratio of the diameter of the body to the diameter of the neck, it is necessary to have a carbon content higher than 3.6 per cent. in order that the passage from the chilled zone to the grey zone will be more pronounced.

The danger of brittle necks is then obviated by placing in the mould, as previously mentioned, iron chills of suitable thickness for densening the surface of the necks. Of course, in order to prevent the latter from being chilled, the chills should be covered with an adequate layer of loam.

Another means which is readily available when the electric furnace is used would be that of superheating the iron (1,550 deg. C.), so that the graphite would tend to dissolve completely, thereby increasing the compactness and improving the mechanical properties. There are not yet sufficient data, however, for recommending this method, which is in the experimental stage, especially as there is reason to believe that if the temperature is increased, the arc tends to graphitise the carbon, rendering it less suitable for combining with the iron.

ECCENTRICITY AND VARIATION IN HARDNESS

In this case, the depth of the chill varies from one point to another, or from one end of the body of the roll to the other, the difference being more marked, the greater the length of the roll. The defect is particularly troublesome because during the turning of rolls intended to be grooved, there is a possibility of the rolls being rejected owing to lack of homogeneity of the chill layer. The causes may be the following:—

Excessively slow pouring which, especially in the case of rolls having a long body, causes the lower part of the chill to be hotter than the upper part, the hardening effect varying between the two ends causing differences in the depth of hardness.

(*Concluded on page 68.*)

Selection and Testing of Cupola Refractories*

By W. J. REES,† M.Sc.Tech., F.I.C.

Cupolas are in general lined in one or other of the three following ways:—(1) With firebricks; (2) with bricks or blocks cut to shape from a natural siliceous rock or "firestone," and (3) with a plastic or semi-plastic material, having either a silica or burned fireclay base, rammed round a former. The firebricks used are normally in the grade with refractoriness in the range of Cone 29 to 32, but under special conditions of melting it may be desirable to use firebricks in the special grade with a refractoriness higher than Cone 32 in the melting zone. Bricks of the "super-refractory" class made from materials such as chrome, calcined or fused alumina, sillimanite, etc., have been used experimentally but their service has not been commensurate with their much higher cost. Silica bricks have generally been ruled out because of their high spalling tendency, but it is not impossible that silica bricks with a clay bond instead of the normal lime bond would give good service (see Table I), as with the change in bond the susceptibility to spalling is decidedly reduced. Silica bricks made from quartzites containing from 1 to 3 per cent. of titanium oxide finely dispersed, when properly graded, have a much higher spalling resistance than bricks made from normal quartzites, and would be likely to behave satisfactorily in the cupola lining. These bricks should be burned to a powder density of 2.36 to 2.40, so that in service there will be a little permanent expansion which will close the joints and prevent slag ingress.

Slag Corrosion

The relative resistance of the fireclay and silica materials to corrosion by cupola slag is indicated in Table I. In making these tests, the refractory material and the slag were ground to powder, mixed together in the indicated proportions, and, after moistening with dextrin solution, made into test cones. The fusion point of these cones was then determined in a gas-fired furnace. The approximate composition of the slag used is SiO_2, 45; Al_2O_3, 5; FeO, 12, and CaO, 35 per cent.

TABLE I.—*Resistance of Firebricks to Slag Corrosion.*

	Slag percentage in mixtures.			
	0	10	25	50
	Fusion points, deg. C.			
Firebrick, 40 per cent. Al_2O_3 ..	1,730	1,580	1,380	1,320
Firebrick, 32 per cent. Al_2O_3 ..	1,690	1,530	1,320	1,240
Firebrick, 24 per cent. Al_2O_3 ..	1,640	1,440	1,250	1,160
Silica brick, 94 per cent. SiO_2	1,710	1,660	1,580	1,150
Cupola ganister, 86 per cent. SiO_2	1,620	1,540	1,460	1,180

It is evident from these tests that from the chemical standpoint aluminous firebricks are likely to be advantageous, but it is necessary to qualify this, because corrosion tests made by placing a pellet of slag (20 to 30 grammes) on a brick and heating for 2 hrs. at 1,500 deg. C. show that although a dense 40 per cent. Al_2O_3 brick is more resistant to corrosion than a dense 32 per cent. Al_2O_3 brick, the latter is more resistant to corrosion and slag penetration than a 40 per cent. Al_2O_3 brick of open texture. It is desirable that cupola bricks and blocks should be of low porosity, hard fired and cleaned burned. With modern methods of brickmaking, such as de-airing, machine pressing, dry-pressing, etc., bricks with porosities in the range 16 to 22 per cent. are being produced, and it is notable that the reduction in permeability is decidedly greater in proportion than the reduction in porosity, as shown in the following recent test results:—

	Porosity. Per cent.	Permeability in C.G.S. units.
Hand-moulded brick ..	27.8	0.25
Machine-pressed from plastic de-aired clay ..	21.0	0.06
Semi-dry pressed with high pressure	19.5	0.05

Another important resultant of the modern methods of brickmaking is that perfection of shape and finish which enables very close jointing of the bricks. It is of importance, too, that the jointing cement used is of high refractory value and small drying and firing shrinkage; the modern refractory air-setting cements are especially worthy of attention.

The volume stability of firebricks in cupola service should be such as will preclude any opening of joints, or bulging of the brickwork. In a reheating test, a test-piece about 3 in. by 2 in. by 1½ in. slowly heated to 1,410 deg. C. and maintained at that temperature for 2 hours (the atmosphere of the furnace containing free oxygen) should not show when cold more than 0.75 per cent. linear contraction or expansion.

It is desirable that the bricks shall contain no segregations of uncombined iron oxide, as these lead to carbon deposition and consequent weakening or disintegration of the bricks from the catalytic dissociation of carbon monoxide. As the optimum temperature for this dissociation and carbon deposition is about 500 deg. C., it is negligible on the inner face of the brick but it may occur nearer the casing where the temperature range will be favourable, and the consequent weakening of the structure of the cooler part of the brickwork may have a detrimental effect on the durability of the lining.

It is necessary, too, that some attention should be given to the mechanical strength of the firebricks at the working temperature. Incidently, the refractoriness-under-load test not only gives information as to the high temperature load-bearing (or pressure-resisting) capacity of a firebrick, but also provides information as to the efficiency of its burning. It is likely that the high-temperature "creep" tests which are being studied at present will provide information which can be applied in the selection of cupola firebricks.

Firestone Blocks

Silica firestone blocks or bricks are not much used in British foundry practice, but their use in American foundries is being followed with interest. The "firestones" which are available in Great Britain are fine-grained sandstones of the following chemical composition:—Silica 92 to 94 per cent.; alumina 2 to 5 per cent.; iron oxide 1 to 2 per cent.; lime 0.2 to 1.0 per cent.; magnesia 0.1 to 0.4 per cent.; alkalis 0.5 to 2.0 per cent., and ignition loss 0.5 to 1.0 per cent. The chemical composition quoted above is not very different from the published analyses of the Ohio bedded silica firestone which is being used successfully in some American foundries, but in the tests made so far the British firestones are less resistant to the thermal shock almost inevitable in the heating-up of a cupola.

Rammed Linings

The plastic or semi-plastic materials are usually highly siliceous, though a few ironfounders use mixtures containing a high proportion of fireclay grog with a bond of plastic fireclay. The siliceous mixtures used for the production of rammed linings and for patching are of two types:—

(*a*) Natural silica "clays" which consist of sand grains in small size uniformly coated with a highly plastic siliceous clay.

(*b*) Silica rocks of "ganister" type which are crushed and ground with a plastic fireclay.

The plastic or semi-plastic siliceous materials fall in silica-alumina ratio between points A and B on the portion of the alumina-silica fusion point curve shown in Fig. 1. It is to be noted that in mixtures containing between 7 and 10 per cent. of alumina (that is 20 to 30 per cent. of an average 30 per cent. alumina fireclay) there is a rapid fall in the fusion point, and that the presence of fluxing impurities in the silica rock and fireclay move the lowest fusion point in the direction of a lower silica-alumina ratio.

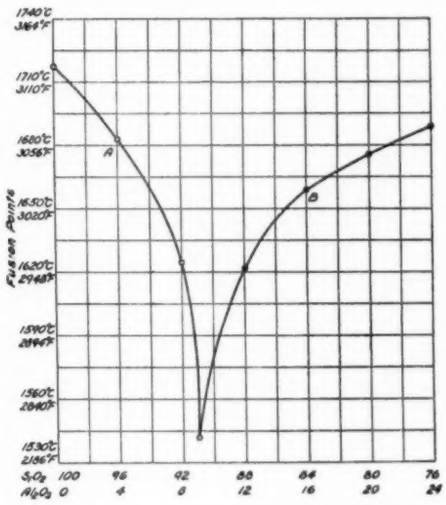

FIG. 1.—FUSION POINT CURVE OF ALUMINA-SILICA.

Occasionally, synthetic mixtures of similar composition to the naturally-bonded mixtures of type (*a*) are made by thoroughly mixing a high-silica sand with a fine-ground plastic refractory clay. It is exceedingly difficult however to obtain by mechanical mixing such uniform dispersion of the clay over the sand grains as is found with the naturally-bonded siliceous materials. With wet mixing the dispersion of the clay is assisted by deflocculating it by the addition of about 0.5 per cent. of a mixture of sodium silicate and sodium carbonate, or by adding the clay in the form of a deflocculated slip.

Synthetic mixtures made with crushed burned fireclay (grog) and a plastic refractory clay are used by some ironfounders. In these mixtures it is essential that the grog used is hard-burned and that the drying and firing shrinkage is small and will not lead to the opening of cracks in the lining. The same considerations as to chemical composition and refractoriness of the grog and clay apply as with firebricks.

Rotary Furnace Linings

In the lining of rotary melting furnaces, mixtures of both the natural and synthetic types are used, but where the melting temperature is

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higher than normal it is advantageous to replace the clay bond with lime, producing a mixture which has a chemical composition and grading comparable with that of a good silica brick. The plasticity and "workability" of the lime-bonded mixtures may be increased by the addition of an organic bond such as dextrin or one of the cheaper by-product bonds of the "sulphite-lye" type. It would seem to be feasible to line a rotary furnace with unburned silica bricks compacted under hydraulic pressure, which would avoid the difficulties of uniform ramming and lamination with granular lining mixtures, and would give a much denser lining. These unburned bricks could be moulded under high pressure with a tongue and groove to facilitate building together. Unburned bricks of this type are being used successfully in the lining of induction furnaces for steel melting.

The function of the clay in the clay-bonded cupola ganisters is primarily to bind the fragments of silica together both in the green and fired condition, but it serves an important secondary purpose in lowering the sintering temperature and causing that incipient fusion of the lining which promotes its mechanical strength and increases its resistance to abrasion and to slag penetration.

Properties of Cupola Lining Materials

To give satisfactory service in the cupola, the materials, whether natural or synthetic mixtures, used for rammed linings, must develop sufficient mechanical strength on drying and heating to resist the stresses set up. When the rammed material is heated it must not only vitrify sufficiently to produce mechanical strength, but it must have satisfactory volume stability, as excessive shrinkage may lead to the formation and opening of cracks, with consequent slag ingress and general weakness. When naturally-bonded materials are used, it is especially important that care should be exercised in working them to "keep to a sample" and avoid variations in bond content or texture. It is possible to improve the properties of some of these natural siliceous materials by making additions to them of high-silica sand or crushed silica rock.

TABLE II.—*Properties of Two Naturally-Bonded Refractory Materials.*

Mechanical grading.

B.S.I. sieves.	1.	2.
	Per cent.	Per cent.
+ 5 mesh ..	0.5	3.5
+ 16 ,, ..	1.5	2.8
+ 30 ,, ..	1.5	5.5
+ 60 ,, ..	2.5	15.0
+ 85 ,, ..	8.0	14.0
+ 100 ,, ..	27.0	10.5
+ 150 ,, ..	21.5	10.0
+ 200 ,, ..	8.0	7.5
− 200 ,, ..	4.0	2.5
Clay grade	25.5	28.7
	100.0	100.0

Chemical analysis of air-dried materials.

	1.	2.	Clay grade from No. 1.
	Per cent.	Per cent.	Per cent.
Silica	76.59	84.02	45.61
Alumina ..	14.70	9.85	35.55
Iron oxide ..	1.90	1.15	2.15
Titanium oxide	0.35	0.32	0.85
Lime	0.74	0.35	0.71
Magnesia ..	0.18	0.22	0.10
Potassium oxide	0.62	0.58	1.24
Sodium oxide ..	0.22	0.24	0.44
Loss on ignition	4.55	3.15	13.25
	99.85	99.88	99.90

The mechanical grading and chemical composition of two typical naturally-bonded materials occurring in Great Britain are set out in Table II.

Both materials give good service in rammed linings, but it is important to keep the moisture content as low as is compatible with adequate workability in ramming to avoid undue drying shrinkage, especially with materials of fine grain-size such as No. 1 above. The effect of water content on drying shrinkage for the above two materials is shown by the figures in Table III obtained with representative samples.

TABLE III.—*Effect of Water Content on Shrinkage.*

Water added to air-dry material. Per cent.	Wet-to-dry shrinkage (linear). Per cent.	
	1.	2.
5.0	0.4	0.5
6.0	0.7	1.0
7.5	1.0	1.2
10.0	1.9	2.0
12.5	2.5	2.5
15.0	3.5	3.0

Both these materials show a permanent expansion of approximately 1.0 per cent. when a dry test-piece is fired at 1,450 deg. C.; this compensates for the drying shrinkage if the added water does not exceed 7.5 per cent. In the forming of rammed linings in the cupola great care must be taken to avoid laminations, as these are likely to lead to spalling of the lining in service. The deleterious effect of laminations in a rammed lining is shown in Fig. 2, which is from the lining of a rotary melting furnace in which trouble was experienced through spalling. The method of ramming used must be such as will ensure complete keying of the layers of material.

FIG. 2.—DELETERIOUS EFFECT OF LAMINATIONS IN A RAMMED LINING INDUCING CONDITIONS PRODUCTIVE OF SPALLING.

Patching Materials

In Great Britain, whilst some foundries use materials such as those detailed above for patching and general maintenance, the majority use materials which are much coarser in fragment size and which are described as cupola ganister. These materials are made by mixing a crushed silica rock containing not less than 92 per cent. silica with from 10 to 30 per cent. of a refractory plastic fireclay, the proportion of clay used depending on the character of the silica rock, the chemical composition and plasticity of the clay, and the required plasticity of the mixture. Photomicrographs of silica rocks used in the production of cupola ganister are shown in Fig. 3 *et seq.* It is desirable that the physical character of the silica rock should be such that when it is crushed it will give angular fragments. Rounded fragments tend to slip over each other, and so lead to weakness, whilst angular fragments tend to interlock, and so promote strength. The plastic fireclays which are used in admixture with the crushed rock have an alumina content (when calcined) between 25 and 35 per cent. and a refractoriness between 1,600 and 1,700 deg. C. In the best practice the silica rock used is of the fine-grained type with 97 per cent. (minimum) silica, and the plastic fireclay of the aluminous type (more than 36 per cent. alumina when calcined) with a refractoriness above 1,700 deg. C. It is important that the matrix of the cupola ganister (*i.e.*, the finer fragments of silica plus the bond clay) should have a chemical composition which is not too near the eutectic (Fig. 1) as this will lead to rapid fusion and possible dripping or running out of the matrix and a "honeycomb" type of corrosion or wear. The use of a refractory clay of a "sticky" nature is advantageous as it will give better bonding in the unfired material, better workability with the minimum proportion of clay, and will allow the use of low water content.

All patching materials must have such characteristics as will enable them to adhere without spalling when heated. After the moist patching material is forced into position, the worn place made good, and the cupola heated, the following cycle takes place:—(1) The water in the material is driven off; (2) the combined water in the bond clay is driven off; and (3) sufficient vitrification is induced to make the patch adhere to the rest of the lining.

It will be seen that a severe condition is set up, and the material used must be one which will withstand the inevitable strain. Patching materials must be used always with only just enough water to give the necessary workability, as over-wetting will not only necessitate slower drying-out, but will also tend to the development of cracks and give a porous patch. Before patching it is, of course, essential that the slag should be removed as completely as possible from the worn place in the cupola.

The actual standardisation of the properties of cupola ganister is made difficult by the great variation in cupola conditions. It is by no means unusual for a ganister mixture which gives good service in one cupola to be totally unsatisfactory in another working under conditions which do not appear to be very dissimilar. It is evident, therefore, that the method of using the ganister has a definite influence on its durability.

Mechanical Grading of Patching Materials

The mechanical grading of a cupola ganister should be such that when it is dried off, and burned, it gives a closely packed lining with a low porosity and permeability. This close packing will also tend to quick and uniform sintering.

To obtain this close packing, the proportion of grains or fragments of middle size should be low, and the proportions of coarse and fine fragments and grains roughly equal. In most cupola ganister miils, the final grading produced is a fortuitous one, but it is possible by control of the grinding time to produce a ganister mixture which has a reasonably satisfactory grading, and which varies very little from batch to batch. It would be preferable, and probably advantageous, first to crush and screen the silica rock and then to mix the necessary proportions of the various screen grades with the proper proportion of fine-ground refractory clay, and finally to wet in a mixer which is so designed as to give thorough mixing without any further grinding. In this way, very complete control of grading, clay proportion, and water content would be possible.

The mechanical grading and chemical composition of cupola ganisters as delivered to iron foundries vary in a larger number of samples

which have been examined within the limits set out in Table IV.

Influence of Moisture

The moisture (*i.e.*, added water) in the materials as used varies between 10 and 20 per cent., and the drying shrinkage is from nil to 2.0 per cent. The volume change of dry test-pieces fired at 1,500 to 1,550 deg. C. varies from a small shrinkage to an expansion of 7 or 8 per cent. A small expansion is preferable to a large expansion or a shrinkage, but where the melting conditions are severe it is essential to have a high silica content in the ganister mixture (bearing in mind, of course, the necessity of keeping clear of the eutectic composition) despite the expansion it will show in service. In addition to drying tests, grading tests, and chemical analyses, there are several useful laboratory tests for cupola ganister.

TABLE IV.—*Average Properties of Cupola Ganister.*

Mechanical grading.	
B.S.I. sieves.	
	Per cent.
+ 5 mesh	3 to 20
+ 30 „	30 „ 40
+ 60 „	4 „ 12
+ 100 „	5 „ 15
− 100 „	30 „ 37
Chemical composition of air-dried materials.	
	Per cent.
Silica	78 to 90
Alumina	5 „ 15
Iron oxide	1 „ 3
Titanium oxide	0.1 „ 0.5
Lime	0.1 „ 0.8
Magnesia	0.1 „ 0.5
Alkalis	0.4 „ 2.0
Loss on ignition	3.0 „ 8.0

Refractoriness

With fine-grained materials cones may be made and their refractoriness determined in the usual manner against standard cones. It is impossible to make cones from the coarse-grained materials, but a useful alternative is to make test briquettes 4 in. by $1\frac{1}{2}$ in. by 1 in. and heat them at 1,550 deg. C. for 4 hrs. With good cupola ganisters there will not be much distortion of the briquette after this heat-treatment, but it will have become vitrified and will have developed considerable mechanical strength.

Slag Resistance

A test briquette 3 in. by 3 in. by 2 in. is made with a cylindrical depression 1 in. dia. and 1 in. deep in the middle of one 3 in. by 3 in. face. This is dried, the depression filled with ground cupola slag, and heated for 2 hrs. at 1,500 deg. C. After cooling the extent of slag penetration and corrosion can be examined by breaking the briquette through across the middle of the depression.

TABLE V.—*Cupola Slag Erosion of Firebrick Tiles Expressed as Inches.*

	Before run.	After run.	Erosion per panel.
	In.	In.	In.
Standard ganister ..	$26\frac{1}{4}$	$27\frac{3}{8}$	0.25
Test material *a* ..	$25\frac{5}{16}$	$26\frac{1}{8}$	0.78
Standard ganister ..	$30\frac{3}{8}$	$31\frac{9}{16}$	0.47
Test material *b* ..	$31\frac{1}{8}$	$31\frac{3}{8}$	0.25

Ratio of erosion of test material *a* to that of the standard ganister, 3 : 1.

Ratio of erosion of test material *b* to that of the standard ganister, 0.5 : 1.

An alternative method for evaluating slag resistance is to make a solid briquette, say 2 in. by 2 in. by 2 in. and, after drying, place on top of it a cylindrical pellet made from about 20 to 30 grammes of ground slag (moistened with a dextrin solution) and then heat for 2 hrs. at 1,500 deg. C. The slag attack is observed after cooling the test briquette. This second method is particularly useful for observing the effect of the porosity and permeability of the ganister on slag penetration as well as its resistance to chemical corrosion. Both methods of test may be amplified by mixing fine-ground iron oxide (iron scale for example) with the cupola slag.

Refractoriness under Load

As the actual pressure due to the weight of the charge in the cupola may have some influence on the effective refractoriness of the cupola lining or patching, it is useful to make tests on dried test-pieces under a load of 28 lbs. per sq. in. (*i.e.*, 2 kg. per sq. cm.).

With the co-operation of Mr. E. S. Renshaw, of Ford Motor Company, Limited, Dagenham, Essex, the Refractories Committee of the Institute have been able to make simulative tests in a cupola fitted with a continuous tapping device. A cupola of this type gives suitable conditions as, after the first tap is made, the cupola well is soon filled with slag only, the metal running immediately into a receiver on reaching the cupola bottom. Test panels 6 in. square by 1 in. thick, backed with thin firebrick tile, are fitted into the cupola well exactly opposite to each other, and are in contact with molten slag for the duration of the run, which is about 7 hrs. The distance between the two panels before and after the run, divided by two, may be taken as the measurement of the erosion. A material of known satisfactory behaviour in the cupola may be used for standard panels alongside the other materials under test. Table V gives the particulars of two materials tested in this way against a standard ganister.

Where a cupola of this type is available this method of test is to be recommended, as it more nearly simulates actual working conditions than any laboratory test for erosion or corrosion.

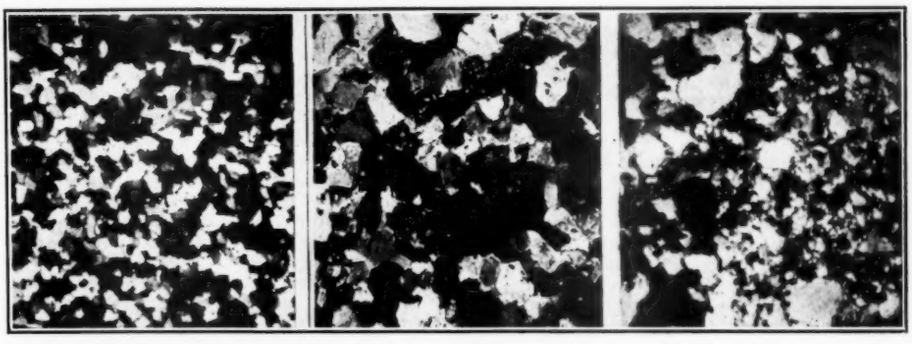


FIG. 3.—GANISTER, SHEFFIELD. FIG. 4.—QUARTZITE, DURHAM. FIG. 5.—QUARTZITE, ANGLESEY.

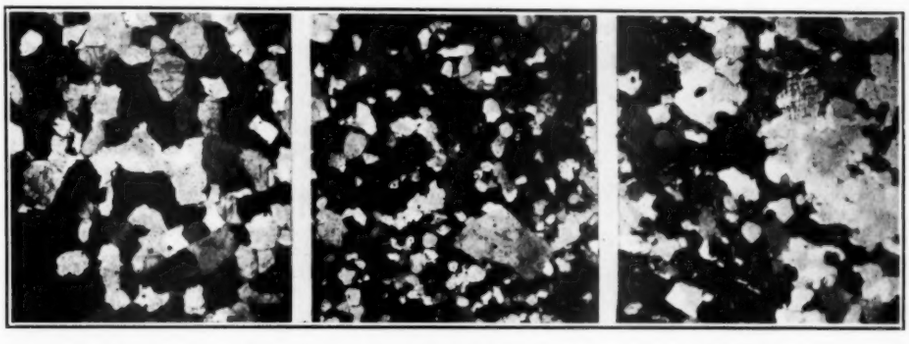


FIG. 6.—QUARTZITE, NORTH WALES. FIG. 7.—QUARTZITE, DERBYSHIRE. FIG. 8.—QUARTZITE, SCOTLAND.

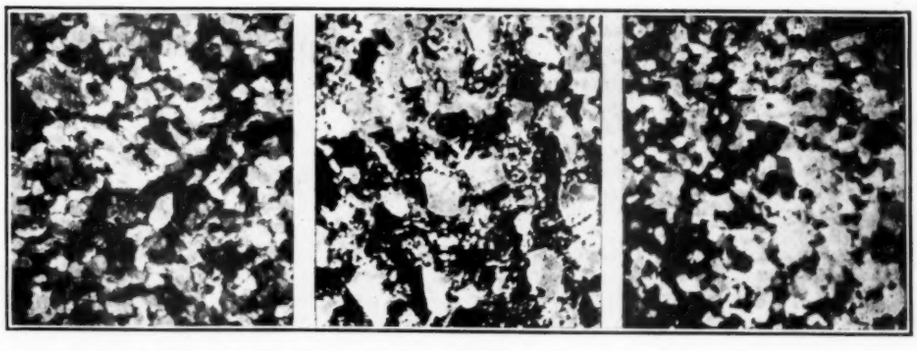


FIG. 9.—QUARTZITE, NEATH (SOUTH WALES). FIG. 10.—QUARTZITE, S. WALES. FIG. 11.—TYPICAL FIRESTONE.

DISCUSSION

MR. J. H. COOPER (Darlington) said that for many years he had been concerned with cupolas, but he failed to see exactly the effect of the slag reduction which Mr. Rees had mentioned, as reducing the temperature of fusion from 1,620 to 1,180 deg. C. He asked what was the

amount of oxide present in the slags when the tests were made, because a cupola always reacted according to the amount of blast and the quality of iron melted—malleable, steel-mix, low-silicon iron, etc.

A good deal of trouble was caused as the result of the wrong method of storing the cupola repairing material when it arrived at a foundry. The manufacturers, having sent a first-class material, would sometimes receive complaints, and when their representatives arrived at the foundry they found that it was not in anything like its original state; it was a combination of old sand, black sand, etc., and the men had to dig it out as best they could.

Brick-Lined Rotary Furnaces

Discussing bricks for lining rotary furnaces, he said one had to consider the expansion of bricks containing a large amount of silica as compared with the contraction of bricks having a high percentage of alumina. In consequence of that difference, one found that in a rotary furnace which was working under stress, the lining was no longer fixed to the casing of the furnace after a few days, so that the lining broke down due to circumstances which were not dependent entirely upon the refractoriness of the material.

In 94 per cent. silica bricks there might be possibilities; but he asked Mr. Rees how he could account for a lining which was reduced to 1,150 deg. C. standing up at all, because in the melting zone of any cupola there must be a temperature of 1,500 or 1,550 deg. C. to give a tapping temperature of approximately 1,400 deg.

Close-Jointed Linings

MR. A. J. SHORE (Birmingham) questioned whether it really mattered that the bricks should be so very close together at the joints as had been indicated by Mr. Rees, and he asked if most cupolas were not protected by a ganister covering. He also asked whether Mr. Rees considered that it would be of advantage to use insulating bricks between the outside of the refractory lining and the shell.

With regard to the use of a lining of ganister rock as a basis for a cupola lining, he asked whether there were in this country any natural deposits of rocks which could be used as substitutes for brick; he had in mind something like the silica stone which was used in America. It seemed that silica bricks were not good things to use in a cupola, due to their spalling, whereas certain natural stones were not prone to that trouble.

Standardisation of Ganister

DR. J. G. A. SKERL asked for the opinion of Mr. Rees as to whether the life of a cupola lining could be affected by more rigid control of the slag in the cupola. He wondered whether, by an increase in the lime charge in the cupola, the life of the lining would be affected.

With regard to ganister, which had been a very "mixed" material, he said the time was rapidly approaching when some sort of standardisation should be attempted for the benefit both of the suppliers and of the users. He suggested that grading was a direction in which the manufacturers could help; but one would like to feel that the constituents of the ganister were materials which were really suitable for the job.

The use of the unburned brick, both in the cupola and in the rotary furnace, offered great possibilities. The unburned brick had been used very successfully in the induction furnace; but in many cupolas a form of unburned brick was used in the rammed linings, and in many cases those rammed linings were giving a very good life, much better, in his opinion, than that of a brick lining. The rammed lining had a composition round about a figure of 94 per cent. silica.

American Practice Discussed

MR. W. R. BEAN (Past-President, American Foundrymen's Association), commenting upon the reference made to the characteristics of the slag from the standpoint of oxide carriers, said that in America that had been found to be one of the most important considerations to makers of cupola linings. Also, the basic and acid elements present played a very vital part in the life of linings and in the results obtained. A great deal of the work in the U.S.A. nowadays involved long hours of operation, and that had given rise to further difficulties in obtaining linings to withstand the heavy blast and pressures, etc., involved in driving cupolas for 8, 12, 14 and sometimes 24 hrs. continuously.

Probably the industry in the United States had not gone so far as had the industry in this country in the adaptation of the rotary furnace to melting operations; it did not quite fit into the picture of foundry operations in the United States. But there were some 12 or 15 rotary furnaces in use there for the production of blackheart malleable iron and some of the pearlitic metals.

The best linings there were found to be of silica brick, which experience had proved to be superior to ganister linings. Records of 5-ton furnaces melting malleable iron showed from 200 to 220 heats, and in one particular case that number of 6-ton heats was obtained, representing a life of from 1,300 to 1,400 tons. Behind that silica brick lining, which was 6 in. thick, there was a permanent lining of fire brick against the shell, also 6 in. thick, so that the total thickness was 12 in. But the lining had to be treated carefully, especially during the initial heating-up. The size of brick used was 3 in. by 6 in. by 12 in., the 12 in. length being longitudinal in the furnace, and an allowance was made for expansion in laying the bricks. There was a paper or cardboard slightly in excess of $\frac{1}{8}$ in. at each of the end joints, and between $\frac{1}{64}$ in. and $\frac{1}{32}$ in. at each of the side joints; so that there was very little spalling when the lining was subjected to temperature, provided the firing was done carefully during the first heats. The furnaces in which those linings were used were turning out metal at 1,370 to 1,600 deg. C. constantly throughout their lives. The linings were easy to build, when once that practice had been established; they were built in much shorter time than was required for the ramming of a ganister lining.

AUTHOR'S REPLY

MR. REES, replying to the discussion, said that the slag which was used in the tests he had illustrated was obtained from a local foundry; it contained 12 per cent. of FeO and 35 per cent. of lime. He agreed with the suggestion made by one or two speakers that the composition of the slag did have a determining effect on the behaviour of the lining, and he agreed with Dr. Skerl that more complete control of slag composition would be helpful in promoting the durability of the cupola lining.

Commenting on Mr. Cooper's reference to the change in the character of the cupola ganister which sometimes occurred between the time it left the yard of the maker and its application in the cupola, he agreed that some iron-founders, at any rate, could with advantage take rather more care in the storing of such raw materials than in fact they did. He had seen cases where trouble had arisen in the application of patching as the result of leaving the ganister exposed to rain, so that it had become over-wetted; nothing was more likely to give rise to trouble in the cupola lining than the use of an over-wet patching material.

The question by Mr. Cooper concerning the expansion of rotary furnace linings had been answered most admirably by Mr. Bean. The reference by Mr. Bean to the use of silica bricks in the linings of rotary furnaces, and the methods adopted for taking up the expansion of the bricks, showed that that type of lining was not only feasible, but could be especially advantageous in a rotary furnace. As Mr. Bean had very properly pointed out, it was very important indeed that silica bricks, and especially well-burned silica bricks, should be heated slowly between 200 and 300 deg. C. Once that particular temperature range was safely passed, and so long as the temperature of the bricks was kept constantly above that range, no spalling trouble was likely to ensue.

South African Titaniferous Bricks

The silica brick referred to in the Paper was clay-bonded and had a lower spalling tendency than the normal lime-bonded silica brick. Another type of silica brick which he believed might be feasible, and indeed was already feasible in one part of the world, was made from a natural quartzite containing from 2 to 3 per cent. of titanium oxide, very uniformly dispersed throughout the rock. A silica brick made from those quartzites, containing from 2 to 3 per cent. of titanium oxide, was for some reason still obscure, very highly resistant to thermal shock. Quartzites with high titanium oxide content occurred in quite considerable quantities in South Africa; he had had the opportunity of examining silica bricks made in South Africa from those rocks, and they were very nearly as resistant to thermal shock as was the average firebrick. They were very much superior in that respect to the normal silica brick one had to deal with in this country.

Dealing with Mr. Shore's remarks concerning jointing, Mr. Rees said he considered that it was advantageous to the durability of the brick lining in any part of the furnace to use good-shaped bricks and close jointing; especially was that so in the upper parts of the lining, where the protection by any patching was much less complete than it was elsewhere.

Insulation of Linings Commended

Insulation was exceedingly important. He believed that, given a much more efficient selection of the highest grades of refractories, it might be possible to insulate the cupola and thereby to improve definitely, not only its thermal efficiency, but also the efficiency of the firebricks, because by the application of a layer of insulating brick between the lining and the case it would be possible to obtain a much more uniform temperature gradient through the bricks themselves and so avoid thermal stresses due to a steep temperature gradient. That matter had exercised many minds. Insulation was being applied successfully in many other types of furnaces, and he would like someone to try it in a cupola and to publish the results.

Written Discussion

MR. E. J. CRAWLEY wrote that Mr. Rees' remarks concerning the ground ganister and the desirability of obtaining standardisation by grading of the ganister rock aggregate were most interesting. However, in considering such an application to plastic mixtures of ganister rock and fireclay, irrespective of the many other types of patching compositions available, one essential property (the importance of which was stressed by cupola operators, and which was difficult to define in the laboratory) had always to be borne in mind, *i.e.*, the property of adhesion to the cupola lining. If a ground ganister was produced to give proper packing of the aggregate and bonded with a minimum amount of fireclay to give plasticity without materially reducing refractoriness, a mixture would be obtained which probably would not be acceptable to the foundry industry, because it would not adhere to the lining. It had been found that the most successful ganisters were those which contained an excessive amount of clay, giving a reduced refractoriness, which had some relation to prevention of the patch flaking off the lining at the beginning of the blow.

(*Concluded on page* 68.)

Radiography in Iron and Steel Founding

DISCUSSION OF MR. F. W. ROWE'S CONGRESS PAPER

The closing technical session of the International Foundry Congress in London was, it will be remembered, a joint meeting with the Iron and Steel Institute, and included among the Papers presented to the meeting was the one on "Radiography in Iron and Steel Founding," by Mr. F. W. Rowe, B.Sc., which was published in the last two issues of the JOURNAL. A report of the discussion on the Paper is appended.

Interpretation of Results

The PRESIDENT (Mr. W. B. Lake) commented that the use of radiography was approached by steel foundries with some misgiving. Steel founders would welcome it in their shops when they could be sure they would be able to put a proper interpretation upon the results shown by the photographs or the visual examination, as the case might be; but they were a little doubtful as to how those results would be interpreted by some inspectors.

DR. GUIDO VANZETTI (President, International Committee of Foundry Technical Associations) emphasised that he would not like his words to be wrongly or in any way interpreted as contrary to the new discoveries of science and progress. Dealing particularly with the use of X-rays in the foundry, he said he noticed a certain apprehension among foundrymen lest this system be made compulsory by the buying authorities, who often had a tendency to adopt any new inspection system even before thoroughly knowing how to use it or how to interpret the results.

Care in Industrial Application

MR. J. H. COOPER (Darlington) congratulated Mr. Rowe on his Paper, and said that since Mr. Rowe had had his X-ray plant he had made wonderful strides, indeed, he had been progressive in many things other than the application of X-rays.

Mr. Cooper recalled that a year or so ago he had spent some weeks in Germany, where he had seen steel and other castings inspected by X-rays, and he had become very keenly alive to the possibilities of the use of X-ray apparatus in the hands of people who could use it, as well as to the possibilities of its use in the other direction by inspectors who could not use it. Just as the difficulty had arisen at the time of the introduction of the sand-blast, that people who came to see it could not appreciate the defects, so it was with X-rays. It was important when using X-rays to ensure that the distance from the piece must be correct, and that the piece must be examined in several positions. The apparatus, used at low amperage and high voltage, could not be put into the hands of any inspector who had not the advantage of intensive training. It was of great importance to avoid under- or over-exposure; a variation of distance of 10 or 20 mm. would result in entirely different readings. The problem of interpretation was a matter calling for the greatest care. By radioscopic methods one could examine small castings on a fluorescent screen with very great rapidity, so that if troubles occurred, as, for instance, where there was a defect at the bottom of the runner, causing tears, etc., one was able to put the matter right before a large number of castings were produced.

The maximum penetration of X-rays into steel was about 5 in., and by reason of that limitation one must take careful note of the differences of cross-section in the casting to be examined. If one were inspecting a casting at an angle in a corner, for example, it must be borne in mind that the maximum depth of penetration was only some 2 or 2½ in., in a direct line at right angles to the edge of the casting.

Ionisation Chamber Method

MR. BENSIMON (Paris) pointed out the importance to be attached to the methods based on the determination of the intensity of X-rays using ionisation chambers. He had seen, for instance, in the laboratories of the Philips' concern, a very simple arrangement comprising two small ionisation chambers in a differential circuit, of which the currents, suitably amplified, light up an incandescent lamp each time when, because of the presence of a defect, the X-rays impinging on the two chambers differ in intensity above a critical minimum.

MR. C. H. KAIN (Braintree) said that the use of X-rays was something which all steelfounders would have to face sooner or later. Perhaps they had been rather afraid of it in the past, and he congratulated Mr. Rowe and his company on their initiative. He asked what degree of experience was necessary in order to interpret correctly either X-ray photographs or visual examinations. Finally, he mentioned jocularly that he rather deplored the sentence in the conclusion of the Paper that there was a quite justified mistrust of castings. It was surprising that the members of the Institute of British Foundrymen had taken that as calmly as they appeared to have done.

Limitation of X-ray Inspection

MR. T. HENRY TURNER, M.Sc. (chief chemist and metallurgist, L.N.E. Railway), replying to Dr. Vanzetti, said it seemed that there would be very little chance of inspectors using X-rays on railway castings. In the first place, the bulk of the foundries were not equipped with the apparatus, and, secondly, the sort of defect it would show most readily, such as bad porosity in a wheel centre for a locomotive, was not really of the greatest importance. A surface crack might be more serious, and there were other methods of inspection which would show up such cracks better than X-rays. Considering the field of steel castings, he said it seemed to him that engineers should be generally much more afraid of cracks than of blowholes. Unfortunately, the X-ray method of testing was particularly weak in regard to small cracks, for the reason that cracks did not penetrate straight into the metal as would a knife blade in a soft material, but persisted in following wriggly paths around grains. Obviously, if one looked along such a path through the straight eye of the X-rays, one's vision was crossing that infinitely small crack many times, and the crack could hardly be expected to show up.

X-rays were useful, however, for the examination of light alloys and welding; in the light alloys there was greater penetration, and in welds there were nearly always thin sections. If, however, one tried to look through perhaps 10 in. of a large steel boss, X-rays could hardly help. So that the answer to Dr. Vanzetti seemed to be that the railways were not contemplating standardising the use of X-rays as an acceptance test. X-ray inspection was expensive per test, which was inevitable for the present. But if the purchaser's inspector did not ask for the use of X-rays, he hoped X-rays would be regarded as a means of investigation which others should use.

He admired greatly Mr. Rowe's courage in installing the apparatus and using it, because, from the foundryman's point of view, it could show more than could be learned from the cutting of a great many sections.

An Aid to Production

MR. G. LUTOSLAWSKI (Warsaw) emphasised the value of constant inspection by means of X-rays in the course of the production of a series of important castings, because the producer could examine the pictures in the early stages of production, could cut out pieces from places in the castings where defects were indicated by the pictures, and determine a certain parallel between the pictures and the pieces themselves. After that, a skilled inspector could determine whether a casting was good or bad by examining the X-ray picture. Of course, that could not be applied to very big castings; but the very big castings were rarely produced in series. Smaller castings produced in series could be inspected in that way, and in Poland they were so inspected with success. In respect of the larger castings, he suggested that the X-ray test could be of use in the hands of the inspectors to help in cases of doubt as to whether a casting was or was not a good one. He knew of specifications which gave inspectors the power to demand an X-ray picture if they thought it necessary. Of course, such work must be only in the hands of the higher inspection staff, and not in the hands of the inspecting operator.

MR. C. D. POLLARD (Derby) paid Mr. Rowe the compliment of being the first steelfounder to install X-ray apparatus for use as an aid to the production of good castings, but wondered whether he was taking steps to educate inspecting authorities in its use. It was not only a question of whether a particular casting had a defect, but the extent of such a defect, and unless the inspector could interpret the X-ray pictures correctly, their use might be a disadvantage from this point of view.

Those who were connected with the steel industry knew that it was almost impossible to produce a sound ingot, yet at times foundrymen were expected to make perfect steel castings, however intricate their design. He was afraid that unless inspecting engineers regarded its use as an aid to judge whether castings were serviceable and not as a further excuse for scrapping castings, the installation of X-ray apparatus was a danger.

The PRESIDENT (Mr. Lake) suggested that before X-rays could be applied to any extent we needed to know more about it. As Mr. Pollard had correctly observed, one could not get every steel casting solid in every part, and more knowledge was needed as to which defects really affected the casting adversely, and which defects were only of minor importance, if of any importance at all. Such knowledge could be attained only by a large amount of hard work, involving the X-ray examination of a whole series of castings which had given good service, together with a series which had failed. By comparison of the two sets of results we should arrive at some solid ground upon which to work.

AUTHOR'S REPLY

MR. F. W. ROWE, B.Sc., replying to the discussion, said that Dr. Vanzetti, in common with a great many other steel founders both in this country and abroad, had some fear that the installation of an X-ray plant might lead to more arduous testing conditions and more rigorous inspection than had been demanded hitherto—on the principle, one supposed, that what the eye had not seen the heart had not grieved about. Whilst his own firm and his own staff were as yet only children in the use of X-rays, such fears as they had had before they had installed their apparatus had since proved to be groundless. He would almost go so far as to say that they had had more castings accepted, due to putting forward X-ray photographs, than they had had rejected.

Very often the inspectors for purchasers of castings saw a defect on the surface which might or might not penetrate a long way; and it was sometimes impossible, due to the nature of a casting, to disclose the full extent of such a defect without spoiling the casting entirely. During their short experience there had been an agreeable number of instances where defects had appeared which had seemed to the founders as likely to be of a minor character, and which the inspector had feared might prove to be major defects, but where the differing opinions had

been settled by an X-ray photograph; that had led to acceptance more often than it had led to rejection.

As to the relative merits of gamma-rays and X-rays, he said they were somewhat similar methods for examining the interiors of castings, but he did not think anyone could say that one method was better than the other or that one method was likely to go further than the other in foundry use. Each had advantages which the other did not possess, and each had disadvantages which the other did not possess. Thus they were both excellent. His very limited experience of the use of gamma-rays would not lead him at the present stage to be more dogmatic than he had been in the Paper, in which he had tried to give a fair and reasonable summary of the relative merits of each method.

Having spent a good deal of time, particularly on the Continent, in studying the application of X-rays to steel and iron foundry practice, Mr. Cooper would appreciate how largely X-ray examination was entering into the production of some really excellent steel castings in Germany, and he was quite right in sounding the warning that mere examination by X-rays was not a cure for all foundry troubles, and that the interpretation of radiographs needed considerable experience and was attended by a fair amount of difficulty.

In reply to Mr. Bensimon and Mr. Kain, he said it was very difficult to put into words how much experience was needed before really dogmatic opinions could be expressed as the result of the examination of a radiograph. One needed almost a lifetime's experience before one could be really dogmatic about radiographs. An experienced man could obtain more or less direct quantitative measurements of the size or location of defects by taking two or three photographs at different angles. Mr. Rowe added that his knowledge of the apparatus mentioned by Mr. Bensimon as having been installed by the Philips' concern was certainly not sufficient to enable him to pass an opinion upon it.

An intelligent man with three months' experience of an X-ray plant could be of considerable assistance in dealing with the simpler kinds of castings, in which variations of section were not very considerable.

Increased Acceptance

Experience with various inspecting bodies had been that in cases of doubt the higher inspecting bodies were likely nowadays to ask that the matter should be settled by expert radiographic examination. For some time it had been obligatory to use X-rays for examining certain aircraft castings in light alloys, and a great many of the light alloy castings now going into service in this country were subjected to 100 per cent. X-ray inspection.

Agreeing with Mr. Turner that X-ray examination was not so valuable as other methods for the examination of surface cracks, he said that presumably Mr. Turner was referring to magnetic tests. The importance or otherwise of purely surface cracks was best evaluated by magnetic tests.

Then Mr. Turner had raised another bogie which Mr. Rowe's experience had not shown to be borne out, in regard to the alleged expense of X-ray testing. The experience of his company was that X-ray testing was very considerably cheaper than cutting up castings. He was afraid that the hacksaw, the milling machine and the cold saw were common tools in the foundries, and that the expense involved in using such tools in connection with the examination of castings was not always realised. It was very seldom that the cutting up of a casting in two or three directions would cost less than 30s. or £2; quite a number of X-ray photographs could be taken much more quickly, and with less disturbance to the shop than was caused by the traditional methods of examining castings.

He was indebted to Mr. Lutoslawski for having put his own thoughts into such concise English, and he endorsed whole-heartedly all that Mr. Lutoslawski had said.

The education of the inspecting authorities, mentioned by Mr. Pollard, was largely in the hands of the steel founders. One felt that if any attempt were made to resist progress, or to damn with faint praise any new method of inspecting castings for soundness, the inspection authorities were likely to insist upon its use; they would assume that there must be something in it, otherwise the producers would not protest against it.

The point raised by the President was one which he had tried to emphasise in the Paper, that a considerable amount of really hard work, perhaps covering 5 or 10 years, was necessary before the X-ray plant would be as readily accepted a tool for metallurgical examination as, say, the microscope, and he urged that, however late the iron and steel founding industry in the United Kingdom might have been in adopting X-ray examination, they ought to do more than they were doing to contribute their full quota to the progress of research on steel and iron castings, particularly having regard to the importance of this country in founding and engineering.

Book Reviews

Maschinenformerei (Machine Moulding). By Prof. Dipl. Ing. U. Lohse. Published by Verlagsbuchhandlung Julius Springer, 22-24, Linkstrasse, Berlin, W.9. Price 2 marks.

This booklet is Vol. 66 of a series of workshop handbooks edited by H. Haake. It runs to 64 pages, contains 129 illustrations, and is divided into four main sections. The first section, dealing with the underlying principles, covers the methods normally employed for ramming sand. The second is devoted to machines for making moulds, and includes notes on hand-rammed stripping machines; hand press; compressed-air machines; jar rammers; press jolters; Sandslingers and other machines of which a pipe-making plant is typical. In the third section, core-making machines are considered, first those incorporating the principles covered in Section 2, and then follow several pages devoted to core blowers. The last section reviews, mainly in tabular form, the application of moulding machinery.

There are signs of overmuch condensation of the matter available, for there are some striking omissions. For instance, no mention is made of magnetic moulding or of the hydraulic system. The examples which are given are mainly drawn from German practice.

Einwandfrier Formguss (Sound Castings). By E. Kothney. Published by Verlagsbuchhandlung Julius Springer, 22-24, Linkstrasse, Berlin, W.9. Price 2 marks.

This is Vol. 30 of a series of workshop handbooks edited by H. Haake. It is the second and revised edition of a book which previously appeared under the title of "Gesunder Guss." It is divided into seven sections, which bear the following headings: The Art and Practice of Making Castings; Underlying Principles of Sound Castings; Composition of the Materials Used for Castings; Testing of Castings; Principles for the Founder; Factors Involved in the Making of Sound Castings, and Tabular Summary of the Subject.

It is the sixth section which calls for major comment, as it again perpetrates the German system of printing a pair of illustrations of designs or moulding methods and labelling one "right" and the other "wrong," instead of dealing with the general underlying principles. There seems to be too little recognition of the adage that "there are more ways of killing a cat, etc." Generally speaking, as the character of the series indicates, the book is fairly elementary.

Defects in Electrically-Melted Chilled Rolls

(*Concluded from page* 62.)

A chill (densener) which is not homogeneous in density, that is to say which, owing to melting defects, such as cavities, porosity or the like, has discontinuities in its mass, will not act uniformly in chilling the molten metal, the latter being hardened more where the chill is more compact than where it is less compact.

Badly distributed blacking with excessive thickness varying from point to point is another cause. In this case the remedies are obvious:—Rapid pouring, employing two pouring gates where necessary. Any defective chills should be removed at once and repaired by building up, or, if this be impossible, they should be scrapped.

At this point it will be appropriate to interpose that the maximum importance should be given to iron from which the chills are cast, which should be very dense and as low as possible in silicon and phosphorus.

The greatest attention should be paid to the distribution of the insulating blacking, a matter which cannot be over-emphasised, since it has been noted that this is the cause not only of the defect at present under discussion, but of numerous other defects.

With this brief, unpretentious account, dictated solely by practice and observations in the foundry, the author has rapidly reviewed the principal defects which confront the foundryman producing chilled rolls, with special reference to rolls produced from iron melted in the electric furnace.

Selection and Testing of Cupola Refractories

(*Concluded from page* 66.)

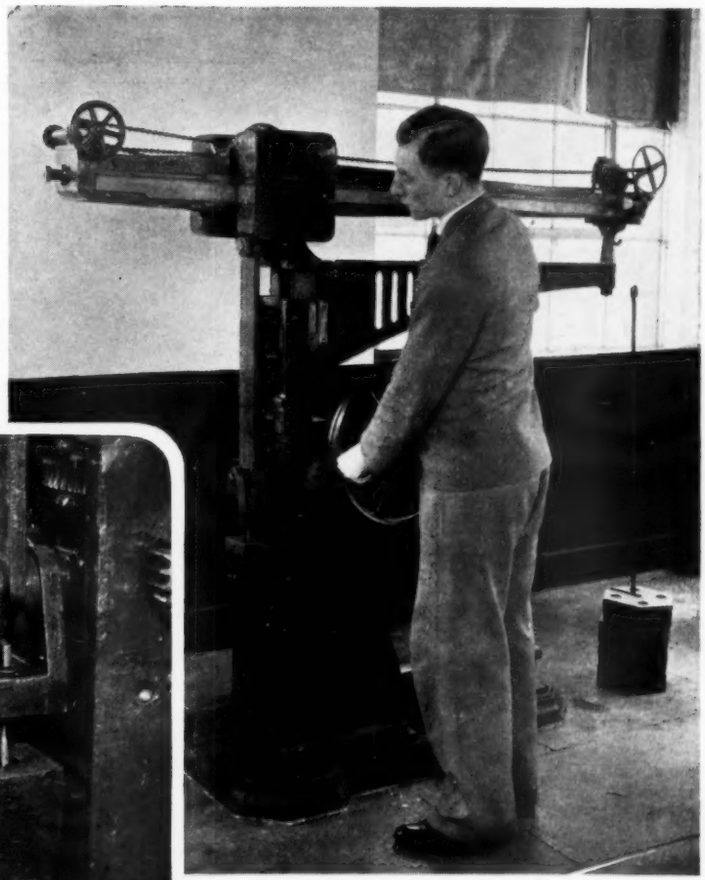
If adequate importance was attached to this factor in designing a "better" ground ganister, the advantages of producing more highly standardised mixtures as regards grading, which at the present time was not controllable to the extent desired, would be fully appreciated.

MR. REES, writing in reply to Mr. Crawley, agreed that the property of adhesion to the cupola lining was an important characteristic of satisfactory cupola ganisters, and he did not intend to convey the idea that the proportion of clay in the mixtures should be so low as to affect their adhesion. He did say that the proportion of clay used should be such that the mixture should not be on, or close to, the silica-alumina eutectic; but it was quite safe, from the refractoriness standpoint, to use a clay proportion which would bring the mixture on to the Al_2O_3 side of the eutectic, as shown in Fig. 1 of the Paper. It should be borne in mind, however, that an excessive proportion of clay, whilst it might increase adhesion to the cupola wall, would tend to form shrinkage cracks on drying and fixing which might not only tend to pull the patching away from the wall, but would also allow slag to penetrate and so lead to rapid corrosion. In considering a cupola ganister with a controlled grading, it should be quite satisfactory to regard the added clay as "fines," especially if added in a finely ground condition.

A Souvenir Brochure

On the occasion of the visit to the works of Thos. Firth & John Brown, Limited, Sheffield, by the guests of the Master and Mistress Cutler who participated in the recent Forfeit Feast, a special brochure was prepared. It is an assembly of annotated photographs dealing not only with every phase of activity at the Atlas and Norfolk Works, but also with those of the associated companies. The liberal use of gold ink gives a distinguished appearance to a production of outstanding merit, and we congratulate the department responsible for its preparation.

GLANTON *for* TENSILES



Tensiles of 12-14 tons per sq. in. are regularly obtained on mixtures using Glanton as a basis.

Analysis

Graphitic Carbon %	Combined Carbon %	Total Carbon %	Silicon %	Sulphur %	Phos. %	Mang. %
3.35	0.35	3.7	2.0-3.5	.02-.04	0.5-0.75	0.7-1.0

Glanton can be confidently used for the general strengthening of all cupola mixtures at small cost. A series of mixtures using Glanton were made in an 18" Cupola to ascertain the strength which could be expected in the average foundry where high grade metal is required. Full particulars are available on application.

The Stanton Ironworks Company Limited, Near Nottingham

The largest producers of foundry pig iron for the free market in Great Britain.

The Week's News in Brief

Trade Talk

THE BRITISH INDUSTRIES FAIR, 1940, will be held from February 19 to March 1.

DAVID BROWN & SON (HUDDERSFIELD), LIMITED, have announced that they are considering expanding their Penistone Works, and plans are under consideration.

IT IS STATED that the Eire Government is interested in an exploratory scheme on the mining rights held by Flemings Fireclay, Limited, at Castlecomer, Co. Kilkenny.

MAURICE G. PARKER, LIMITED, technical advertising and business consultants, are changing their address on July 29 from 16, Bennett's Hill, to 3, New Street, Birmingham.

THE OFFICES of Beralt Tin & Wolfram, Limited, and the British (Non-Ferrous) Mining Corporation, Limited, have been removed to Westralia House, Gresham Street, London, E.C.2.

FOR THE third year in succession, employees of H. M. Biggleston & Sons, brass and ironfounders, of Canterbury, took part in a week-end trip to Belgium as their annual outing.

A PRELIMINARY CONFERENCE to review the state of the shipbuilding industry in relation to wages, asked for by the Confederation of Shipbuilding and Engineering Unions, is to be held at Edinburgh to-day.

EXTENSIONS are to be made by Jarrow Metal Industries, Limited, as a result of a contract from the Government for equipment in connection with the R.A.F. expansion plan. The extensions, which will be completed in seven or eight months, will result in employment for another 750 workers.

THE BOW of the German battle-cruiser "Derrflinger" (26,700 tons), which was scuttled at Scapa Flow after the war, was raised to the surface last Monday by Metal Industries, Limited, Glasgow. The firm recently announced that operations would be suspended after raising the "Derrflinger," leaving two battleships on the ocean bed.

THE ANNUAL REPORT presented at the congress of the Federation of Chambers of Commerce of the British Empire in London last Friday states that imports into the United Kingdom from Empire countries constituted a record in 1938, being 40.39 per cent. of total imports. The proportion has steadily risen from 28.9 per cent. in 1931. United Kingdom exports to Empire countries also constituted a percentage record, 49.87.

THE MINISTER OF SUPPLY proposes, as the work of the Ministry develops, to associate with it advisory panels to assist in regard to the different branches of the work of the Ministry. The first of these will be an Advisory Industrial Panel, and the following have agreed to serve on it:—Mr George Bailey, Mr. Peter Bennett, Mr. Oliver Boden, Commander Sir Charles Craven, Mr. C. R. F. Englebach, Lord Dudley Gordon, Mr. A. J. Grant, Sir Alfred Herbert, Sir James Lithgow, Mr. A. C. Macdiarmid, Mr. F. E. Rebbeck, Mr. J. Rogers, and Lord Woolton.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"HI-HIGH" (CIRCULAR DEVICE).—Die-casting machines. Madison-Kipp Corporation, c/o Marks & Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2.

"MAGNAL."—Metals. Magnal Products, Limited, Tower Road, Warmley, Gloucestershire.

"HOWCANS."—Refractory bricks. Joseph Morton, Limited, Cinder Hills Fire Clay Works, Halifax.

"PERMAMOLD."—Metal castings. Fachanstalt für Neuzeitliches Giessereiwesen Dipl. Ing. Dr. Ing. L. Weiss Gesellschaft mit Beschränkter Haftung, c/o Frank B. Dehn & Company, Kingsway House, 103, Kingsway, London, W.C.2.

"AQUARIST."—Foundry casting powder. District Chemical Company, Limited, 52 to 54, Leadenhall Street, London, E.C.3.

"CROBALITE."—Non-ferrous metal alloys. Temple Metal Company, Limited, 106, Edmund Street, Birmingham.

Personal

MR. S. V. TOY has resigned his position as technical director of Davy & United Roll Foundry, Limited, Billingham.

MR. A. B. HOLMSTROM, general manager of the Norton Grinding Wheel Company, Limited, Welwyn Garden City, is leaving to take over the general managership of the parent company in Worcester, Mass., U.S.A. A dance given in his honour at the firm's sports club was attended by about 170 of the firm's employees and friends.

MR. W. G. GIRLING, who is vice-chairman and managing director of Henry Foster & Company, Limited—an associated company of General Refractories, Limited—has been appointed a director of General Refractories, Limited, and of the Glenboig Union Fire Clay Company, Limited, Scotland. Mr. Girling has had a lifelong association with the refractories industry, and the company with which, in the past, he has been primarily interested, is well known internationally for blast-furnace linings.

MR. W. G. GIRLING.

Obituary

MR. WALTER PERKS, who was associated with the Horseley Bridge & Engineering Company, Limited (now Horseley Bridge & Thos. Piggott, Limited), of Tipton, during the whole of his working life, died on July 13, aged 75. Joining the firm as an office boy at the age of thirteen, he rose to be a director and general manager, holding the latter position from 1914 until his retirement in 1927.

THE DEATH occurred in Glasgow last Saturday of Mr. W. A. Boyd, who was a director of J. & T. Boyd, Limited, textile engineers and ironfounders, of Shettleston Ironworks, Glasgow. Throughout his business career Mr. Boyd was associated with the firm, which was founded by his father, Mr. T. A. Boyd, and his uncle, Mr. John Boyd. He represented the firm in Manchester for several years.

Company Reports

Mather & Platt, Limited.—Interim dividend of 4 per cent.

Crossley-Premier Engines, Limited.—Net profit for year to April 30, £34,914; dividend of 10 per cent.

Head, Wrightson & Company, Limited.—Dividend of 7½ per cent., making 10 per cent. for the year to April 30 last.

Kay & Company (Engineers), Limited.—Net profit for the year ended May 31 last, £26,460; dividend on the ordinary shares of 15 per cent.

Aeroplane & Motor Aluminium Castings, Limited.—Net profit for year to March 31, before allowing for taxation, £37,879; dividend of 15 per cent.

Head, Wrightson & Company, Limited.—Net profit for the year to April 30, £85,178; brought in, £12,225; general reserve, £40,000; to pensions reserve, £10,000; final dividend on the ordinary shares of 7½ per cent., making 10 per cent. for the year; carried forward, £17,022.

Davy & United Engineering Company, Limited.—Net profit for the year ended March 31, £83,435; brought in, £37,930; dividend of 7½ per cent., £36,000; directors' additional remuneration, £4,172; reduction of the value of the consideration for trading and manufacturing agreement with United Engineering & Foundry Company, £7,500; carried forward, £73,693. Meeting, August 11.

Davy & United Engineering Company

ACQUISITION OF DUNCAN STEWART SHARES

An extraordinary general meeting of Davy & United Engineering Company, Limited, is to be held at Sheffield on August 11, following the annual general meeting, to alter the Articles of Association and to consider a resolution providing for the acquisition of shares in Duncan Stewart & Company, Limited. It is proposed that the capital of the company be increased to £750,000 by the creation of 250,000 new shares of £1 each, 125,000 shares of which are to be issued with a view to the acquisition of not less than 90 per cent. of the issued share capital of Duncan Stewart & Company, Limited, and 2,500 shares are reserved for issue to the United Engineering and Foundry Company. The remaining 122,500 new shares are for the general purposes of the company and will rank for dividend as from the date of issue. The 125,000 shares in connection with the Duncan Stewart issue and the 2,500 for issue to the United Engineering & Foundry Company will rank for dividend as from April 1 last.

Duncan Stewart & Company Limited, are well-known steelworks engineers, with works at Bridgeton, Glasgow. The company has a capital of £200,000 in £1 shares.

The annual report of Davy & United Engineering Company, Limited, states that the acquisition will provide additional works capacity and is being effected in pursuance of the directors' policy of providing a greater engineering service within one group.

In connection with the acquisition, Mr. E. J. Fox, chairman, and Mr. W. Reid, managing director of Davy Engineering, will join the board of Duncan Stewart, and Mr. J. B. Talbot-Crosbie, chairman, and Mr. W. Kilpatrick, director of that company, will join the board of Davy Engineering.

Light-Castings Federation Appoint Technical Adviser

The National Light Castings Ironfounders' Federation has recently added to its staff by appointing Mr. Charles Gillespie, the late foundry manager of the light-castings department of Newton, Chambers & Company, Limited, Sheffield, to the position of technical adviser to the Federation.

The Federation has had under consideration for some time an appointment of this nature, as new agreements and changing conditions have made obvious the necessity of having on the staff a man of practical experience who would be available to devote his whole time to the settlement of these difficulties.

Mr. Gillespie is a man of wide technical and practical experience, having been engaged in the foundry trade for 31 years. He was trained as a moulder with the Abbots Foundry Company, Falkirk, and thereafter served in the foundries of Shanks & Company, sanitary engineers, Barrhead; Ideal Boilers & Radiators, Hull; and latterly as works manager in the light-castings department of Newton, Chambers & Company, Sheffield, which position he held for almost eight years, during which time he had control of approximately 300 workmen.

In addition to his practical experience Mr. Gillespie completed a course of study in foundry practice at the Falkirk Technical School and at the Royal Technical College, Glasgow. He has a thorough knowledge of up-to-date methods of production and plant and a wide experience in the fixing of rates and methods of payment, with particular reference to rainwater goods, stove grates and general castings, as regards both the production of these castings and the various finishing processes. His appointment should prove of great practical benefit to the Federation in dealing with questions arising on the practical and technical sides.

THE DEATH has occurred of Mr. J. W. Coates, director and secretary of George Keighley, Limited, Bank House Ironworks, Burnley. He was associated with the firm for 44 years.

THIS WHEELABRATOR

replaces three Sand Blast Plants!

AT
Messrs. NEWMAN HENDER & Co., Ltd.
WOODCHESTER.

TAKE the power alone used by three Sand Blast plants. Then add three operators, a large air compressor and motor, air receiver, hose, nozzles, maintenance, and a great deal of space. Reckon up the cost. Then do away with the lot and install one Airless Wheelabrator Tum Blast, needing 15 h.p., one operator and amazingly little room. You will find, like Messrs. Newman Hender did, that it easily accomplishes more work than the three pressure plants put together. The Wheelabrator is a definitely economical proposition, which it is in your interests to investigate. Write to-day for particulars or ask our representative to call.

TILGHMAN'S

PATENT SAND BLAST CO., LTD., BROADHEATH, Nr. MANCHESTER

1118 M. London Office: 17, Grosvenor Gardens, S.W.1

Birmingham.

ward, £73,693. Meeting, August 11.

with the firm for 44 years.

Raw Material Markets

Most producers of high-phosphorus foundry pig-iron have only small stocks, but this is no justification for any expansion in the output, as the demand continues to be very quiet and consumers are only ordering small parcels as the need arises. The turnover in low-phosphorus iron and in hematite, on the other hand, is quite considerable, while basic, too, is well taken up by the steelworks.

Pig-Iron

MIDDLESBROUGH.—Trade in foundry iron continues to be at a low ebb. Local requirements are disappointing, and what demand does exist is frequently satisfied by producers in other districts, who are able to deliver iron at prices which compare favourably with Cleveland material. There are no indications of a revival in the export demand, which remains very quiet. Consumption of hematite continues to expand both at makers' own works and among ordinary users, who are specifying deliveries much more freely than they did before the price reduction came into operation at the beginning of the current month. There is some export business being transacted, but generally only small tonnages are involved. The entire output of local basic iron is requisitioned by the steelworks, who are accepting deliveries of very substantial amounts.

LANCASHIRE.—A feature of the holiday season in this area this year has been that it has been allowed to interfere as little as possible with the sequence of work at those plants which are in the position to maintain full-time working. Heavy electrical engineering concerns and makers of machine tools are operating to capacity, but most other sections are still short of work, especially textile-machinery makers, jobbing foundries and makers of light castings; the first-named are expecting an improvement in the near future, but little sign of better conditions is available as yet. Satisfactory tonnages of hematite continue regularly to change hands.

MIDLANDS.—Dull conditions continue to prevail in the high-phosphorus iron trade, and, generally speaking, users are content to buy on a hand-to-mouth basis. Some expansion in the demand has recently been noticeable, although this is as yet very slight. The large ironfoundries, which are very busy on Government orders, are taking up substantial supplies of hematite. Business in low-phosphorus iron has recently fallen off to some extent, as most consumers have already covered their requirements over some months ahead—in some cases up to the end of the year. Consumption continues to be on a heavy scale, and will remain so while many users are engaged on rearmament work.

SCOTLAND.—There is little to report this week, owing to the Glasgow Fair holidays. Works generally did not reopen until Monday, since when business has been quiet. Founders in the Falkirk district have reopened after their vacation, but trade continues to be unsatisfactory, and little hope is held of any early improvement. The steelworks have restarted their plants at capacity working, and these conditions will no doubt continue to prevail for many months.

Coke

Despite the fact that many consumers of foundry coke have already covered their requirements over some months to come, in certain instances up to the end of the year, there is still quite a firm market, with the demand brisk. For delivery to Birmingham and Black Country stations, best Durham coke and Welsh coke will be quoted at a minimum of 50s. 6d. per ton, at least until the end of the year, when prices will come up for review.

Steel

Orders for structural steel continue to be placed as freely as production will allow by constructional engineers, shipbuilders and other consumers, and outputs have been accounted for over a considerable period ahead. Similar conditions obtain in most sections of the steel industry, and home production of certain descriptions is inadequate fully to meet the demand, so that imports have to be accepted. In many areas imports have been substantially higher this month than last, and promise further to expand. Even so, congestion at some makers' works is such that consumers are having to wait considerable periods for deliveries. Light sections are also difficult to procure without delay, largely owing to a shortage of steel billets. Sheet makers and galvanisers continue to operate to full capacity and new orders are having to be refused quite frequently in order that works may deal satisfactorily with existing commitments.

Scrap

Most classes of iron scrap are now obtainable without much difficulty, while steel-scrap supplies are also more plentiful, but additional imports are arriving and a ready market is available. Full controlled prices, of course, continue to be charged for all business in steel scrap. Cast iron is being used in heavy tonnages by concerns connected with rearmament projects, and available supplies are passing into consumption freely.

Metals

Copper.—Much of the activity in this market continues to be on contract account, consumers being unwilling to book ahead whilst the tension in Europe and the Far East remains. The market in London has been strengthened by favourable reports from the United States. In that country copper shares have been particularly firm of late, and the price of domestic metal has been advanced further, by ⅛ cent, to 10.37 cents per lb. This was somewhat surprising, as sales recently have fallen away following the heavy tonnages which changed hands a few weeks ago. A Paris report states that a number of French banks have opened a substantial credit in favour of leading copper consumers in France for the purchase of American copper in the United States.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £42 13s. 9d. to £42 15s.; Friday, £42 13s. 9d. to £42 15s.; Monday, £42 17s. 6d. to £42 18s. 9d.; Tuesday, £42 18s. 9d. to £43; Wednesday, £43 to £43 1s. 3d.

Three Months.—Thursday, £43 to £43 1s. 3d.; Friday, £43 to £43 1s. 3d.; Monday, £43 3s. 9d. to £43 5s.; Tuesday, £43 5s. to £43 6s. 3d.; Wednesday, £43 5s. to £43 6s. 3d.

Tin.—Industrial demand for this metal remains on the quiet side, but prices are unchanged. A few small American orders have recently been placed, but business from that quarter does not expand very materially. A recent report issued by C. S. Trench & Company, Inc., of New York, states that "an essential service which the International Tin Committee might perform is to authorise the executive of the buffer stock to make public the tonnage held in the pool and the quantity of tin bought or sold on balance for which contracts have not matured. It is understood that this information is available to the members of the International Tin Committee, but in the interests of the trade, and in the furtherance of the goodwill of consumers, the position of the buffer stock should be available to all and not solely to some parties. The tin industry has never really profited from the curtain which has hidden essential features of the situation from public view."

According to advices from La Paz, Bolivia, the new Government decree, which came into force on July 16, will impose strict regulations on Bolivian tin exports. It is understood that the Government has planned to build up a stabilisation fund by a 2½ per cent. tax on all tin exports, which will be used to compensate for world price fluctuations. Exporters must leave on deposit at the bank 5 per cent. of their receipts in a reserve fund of foreign currency to meet all emergencies.

Official quotations were as follow :—

Cash.—Thursday, £229 17s. 6d. to £230; Friday, £229 17s. 6d. to £230; Monday, £229 17s. 6d. to £230; Tuesday, £229 17s. 6d. to £230; Wednesday, £229 17s. 6d. to £230.

Three Months.—Thursday, £224 15s. to £224 17s. 6d.; Friday, £224 15s. to £225; Monday, £225 to £225 5s.; Tuesday, £224 15s. to £225; Wednesday, £224 15s. to £225.

Spelter.—The demand for this metal has been only moderate during the past week, and the tone of the market is rather quiet. However, consumption is quite well maintained, and some consumers are taking up satisfactory deliveries under existing contracts. The apparent failure in connection with negotiations to re-establish the International Zinc Cartel has not encouraged purchasers to buy ahead.

Daily market prices :—

Ordinary.—Thursday, £14; Friday, £14 1s. 3d.; Monday, £14 3s. 9d.; Tuesday, £14 6s. 3d.; Wednesday, £14 6s. 3d.

Lead.—The Ministry of Labour returns of the building trade for the month of June reveal that there was a decline of 29 per cent. in the value of dwelling house plans passed during that month, as compared with the corresponding month of last year. This was offset to some extent, however, by the plans for factories and workshops, which showed an advance of 66 per cent. and for shops and business premises, which increased by 40 per cent. The total plans passed in June for all types of buildings was lower by 12.2 per cent. as compared with June of last year.

There continues to be a fairly ready demand for available supplies of lead, chiefly from concerns engaged on armament work. Cable and battery works are generally well employed, but the consumption of lead in the building trade leaves much room for improvement. Consumers in the United States are buying on a fairly large scale.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 13s. 9d.; Friday, £14 12s. 6d.; Monday, £14 13s. 9d.; Tuesday, £14 15s.; Wednesday, £14 13s. 9d.

Scrap.—Business has been maintained at its recently improved level, and substantial tonnages are being ordered, especially from abroad. Refining metal is being taken up by German users, while the United States has recently been in the market for heavy supplies of duralumin.

Approximate selling prices for old metal are as follow:—New aluminium cuttings, £72; rolled, £62; cast, £31 to £35; foil, £80. Copper, £39 to £43; braziery, £37. Brass (clean), £23 to £26. Zinc, £9. Lead, £13 15s. Gunmetal, £39.

Contracts Open

Alexandria, August 21.—Two electrically-driven pumping sets, for the Ports and Lighthouses Administration. (D.O.T. reference : T.Y. 24,916/39.)

Cairo, August 9.—Supply and erection of an artesian 6-in. pipe and a Diesel engine-driven pumping set, for the Egyptian Ministry of Public Works (Mechanical and Electrical Department). (D.O.T. reference : T. 24,914/39.)

Hitchin, August 3.—Construction of 1,400 yds. of 4-in. cast-iron mains, for the Rural District Council. D. Balfour & Sons, civil engineers, 47, Victoria Street, Westminster, London, S.W.1. (Fee £2, returnable.)

Leek, August 1.—Construction of 3,150 yds. of 3-in. cast-iron mains, for the Rural District Council. Mr. S. Gibson, engineer, Biddulph, Stoke-on-Trent. (Fee £2 2s., returnable.)

New Malden, July 31.—Supply and erection of a weighbridge, for the Malden and Coombe Town Council. Mr. A. R. Goldthorp, borough engineer, Municipal Offices, New Malden, Surrey.

Rugby, August 4.—Pumping machinery, for the Town Council. The Water Engineer, "The Lawn," Newbold Road, Rugby.

Wolverton, July 31.—400 tons of 7-in., 12-in. and 15-in. spun-iron pipes, together with cast-iron specials, for the Urban District Council. W. H. Radford & Son, consulting engineers, Albion Chambers, King Street, Nottingham. (Fee £3 3s., returnable.)

New Companies

Eric Mills, Limited, 113/117, Greenhill Grove, Manor Park, London, E.12.—Capital, £500. Ironfounders, sheet-metal workers, etc. Directors: E. R. Taylor and C. G. Mills.

Foundry Plant & Machinery, Limited, 113, West Regent Street, Glasgow.—Capital, £7,350. To acquire the whole or any part of the share capital, debentures, debenture stock, and other interests, and take over all or any of the liabilities of Foundry Plant & Machinery, Limited. Directors: H. J. Kennard, W. M'Farlane, W. W. Mitchell, W. Rennie, D. Sharpe, and A. W. Steven.